COMPARATIVE ANALYSIS OF SPRING FLOOD RISK REDUCTION MEASURES IN ALASKA, UNITED STATES AND THE SAKHA REPUBLIC, RUSSIA

By

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Abstract

River ice thaw and breakup are an annual springtime phenomena in the North. Depending on regional weather patterns and river morphology, breakups can result in catastrophic floods in exposed and vulnerable communities. Breakup flood risk is especially high in rural and remote northern communities, where flood relief and recovery are complicated by unique geographical and climatological features, and limited physical and communication infrastructure. Proactive spring flood management would significantly minimize the adverse impacts of spring floods.

Proactive flood management entails flood risk reduction through advances in ice jam and flood prevention, forecasting and mitigation, and community preparedness. With the goal to identify best practices in spring flood risk reduction, I conducted a comparative case study between two flood-prone communities, Galena in Alaska, United States and Edeytsy in the Sakha Republic, Russia. Within a week from each other, Galena and Edeytsy sustained major floods in May 2013.

Methods included focus groups with the representatives from flood managing agencies, surveys of families impacted by the 2013 floods, observations on site, and archival review. Comparative parameters of the study included natural and human causes of spring floods, effectiveness of spring flood mitigation and preparedness strategies, and the role of interagency communication and cooperation in flood risk reduction.

The analysis revealed that spring flood risk in Galena and Edeytsy results from complex interactions among a series of natural processes and human actions that generate conditions of hazard, exposure, and vulnerability. Therefore, flood risk in Galena and Edeytsy can be reduced by managing conditions of ice-jam floods, and decreasing exposure and vulnerability of the at-risk populations. Implementing the Pressure and Release model to analyze the vulnerability

progression of Edeytsy and Galena points to common root causes at the two research sites, including colonial heritage, unequal distribution of resources and power, top-down governance, and limited inclusion of local communities in the decision-making process. To construct an appropriate flood risk reduction framework it is important to establish a dialogue among the diverse stakeholders on potential solutions, arriving at a range of top-down and bottom-up initiatives and in conjunction selecting the appropriate strategies.

Both communities have progressed in terms of greater awareness of the hazard, reduction in vulnerabilities, and a shift to more reliance on shelter-in-place. However, in neither community have needed improvements in levee protection been completed. Dialogue between outside authorities and the community begins earlier and is more intensive for Edeytsy, perhaps accounting for Edeytsy's more favorable rating of risk management and response than Galena's.

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List of Abbreviations

ADHSEM	Alaska Department of Homeland Security and Emergency Management
CCHRC	Cold Climate Housing Research Center
EWS	Early Warning System
FEMA	Federal Emergency Management Agency
FRRRA	Spring Flood Relief, recovery, and Restoration Agency
GAR	Global Assessment Report
GFDRR	Global Facility for Disaster Reduction and Recovery
GILA	Galena Interior Learning Academy
HFA	Hyogo Framework for Action
IFRC	International Federation of Red Cross and Red Crescent Societies
IPCC	Intergovernmental Panel on Climate Change
IRDR	Institute for Risk and Disaster Reduction
LBWM	Lena River Basin Water Management Agency
MChS	Ministry for Civil Defense, Emergencies and Elimination of Consequences of Natural Disasters (also known as EMERCOM)
NAS	National Academies of Sciences, Engineering, and Medicine
NGOs	Non-Governmental Organizations
NWS	National Weather Service
PAR	Pressure and Release model
RFC	Alaska-Pacific River Forecast Center
Roshydromet	Russian Federal Service for Hydrometeorology and Environmental Monitoring
TCC	Tanana Chiefs Conference
UN	United Nations
UNISDR	United Nations Office for Disaster Risk Reduction
UNOCHA	United Nations Office for Coordination of Humanitarian Affairs
USAF	United States Air Force
WHO	World Health Organization

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Dedication

I dedicate this work to my Father Yevgeniy Kontar, who has always pushed me beyond what I thought were my limits, and supported me every step of the way.

1. Introduction

This dissertation responds to the need for disaster risk reduction to minimize the adverse impacts of catastrophic floods in rural northern communities during springtime river ice breakup. Taking its origin at the end of the twentieth century, disaster risk reduction is a relatively new concept in disaster research and management (Cutter et al., 2015; United Nations International Strategy for Risk Reduction [UNISDR], 2015). Disaster risk reduction is a conceptual framework that entails the development and application of policies and practices to lessen a population's vulnerabilities and disaster risks. It incorporates disaster preparedness, mitigation, and prevention within the broad context of a community's sustainable development (UNISDR, 2009; Intergovernmental Panel on Climate Change [IPCC], 2012; Wisner, Gaillard, & Kelman, 2012).

The underlying idea behind disaster risk reduction is to proactively manage disaster risk to minimize and ideally prevent its adverse impacts, as opposed to reacting to the disaster crisis. Hence, disaster risk reduction calls for upfront investments (Kellett & Sparks, 2012; Palmer, 2013; Cutter et al., 2015). Today, the disaster research community largely agrees that these upfront investments will pay off in the long run by reducing or even eliminating immense reconstruction and recovery costs, and most importantly loss of life (e.g., Ismail-Zadeh & Takeuchi, 2007, Kellett & Caravani, 2013; Watson, Caravani, Mitchell, Kellett, & Peters, 2015; UNISDR, 2015; Zweynert, 2017). Disaster policies, nevertheless, remain predominantly reactive (Cutter et al., 2015; Zweynert, 2017).

Palmer (2013) and Cutter et al. (2015) addressed this contradiction by explaining that disaster risk reduction puts long-range investments in competition with short-term political cycles. It is more politically advantageous to respond to disasters when constituents are asking for help. Since "hazard mitigation is not a vote-winner," disaster crisis management policies, which focus on disaster response, prevail (Cutter et al., 2015).

The potential benefits of a more proactive disaster management approach are especially evident in high latitudes, where disaster response is challenged by the region's unique geographical and climatological features. Brutal weather, vast distances, limited physical and communication infrastructure, and seasonal lack of daylight pose significant obstacles to emergency response in the Circumpolar North[1] (hereafter North) (Kravitz & Gastaldo, 2013).

Inadequate risk assessment and emergency training further complicate disaster response in many parts of the North (Institute for Risk and Disaster Reduction [IRDR], 2014; Benoit, L., 2014). Disaster practitioners' reports from Alaska (USA) and the Northwest Territories (Canada), for instance, have repeatedly indicated many complications and delays during disaster relief operations. In most cases, federal assistance is crucial, but rarely timely. Major emergency responses (i.e., national disaster responses) are launched from the southern hubs in lower latitudes, which are relatively long distances away from the impacted communities. Responders from the south are often unfamiliar with the geographic area, as well as the unique logistical and cultural features of the North. Moreover, processes used to trigger federal assistance vary between jurisdictions, creating additional complications and delays in disaster relief (IRDR, 2014; Benoit, L., 2014).

Furthermore, future climate prediction reports suggest there will be an increase in frequency and intensity of some climatological and hydrological disasters (UNISDR, 2008; IPCC, 2012; National Academies of Sciences, Engineering, and Medicine [NAS], 2016; Slater & Villarini, 2016). Considering everything mentioned above, not investing in disaster risk

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[1] In the context of this dissertation, the Circumpolar North is referred to the area traditionally covered by the terms *Arctic* and *Subarctic*.

reduction in the North and continuing to rely predominantly on disaster response and crisis management will ultimately put many northern peoples and communities at risk.

Through the review of academic literature and professional reports in the fields of disaster risk reduction, and disaster risk in the North, I found three main trends:

1. Disaster risk reduction research has been predominantly focused on megacities and urban areas, thus underrepresenting the risk in rural communities (UNISDR, 2015; International Federation of Red Cross and Red Crescent Societies [IFRC], 2016a). Birkmann, Welle, Solecki, Lwasa, and Garschagen (2016) explained this trend by the fact that economic assets and political power typically concentrate in large urban areas. Yet in the Arctic, the rural communities are the remaining reservoirs of Indigenous lifestyles, languages, and cultures.
2. Disaster risk in the North has been primarily concerned with coastal flooding and erosion (e.g., IRDR, 2014; NAS, 2016), and oil spills (e.g., Rossi, 2013; IRDR, 2014). Lately, the former have also been receiving a lot of attention from national and international media (e.g., Sackur, 2013; Semuels, 2015; Kennedy, 2016), thereby further setting apart their scientific and societal importance from other hazards. The latest trend in circumpolar disaster research incorporates mishaps with tourist ships (e.g., IRDR, 2014; Benoit, L., 2014).
3. In most cases, disaster risk reduction in the North is coupled with climate change adaptation (e.g., Brunner et al., 2004; Ford & Smit, 2004; IPCC, 2012; Clement, Bengtson, & Kelly, 2013; Kelman, Gaillard, & Mercer, 2015). This long-term perspective is crucial for the sustainable development of northern communities. However,

it also neglects the immediate adverse impacts of disasters that are happening now. As a result, people continue to suffer.

This dissertation contributes to the existing research in the fields of disaster risk reduction and disaster risk in the North by expanding knowledge in the following areas: 1) disaster risk reduction in rural northern communities, 2) inland riverine flooding in the North, and 3) reduction of immediate disaster risks. Via a comparison between two case studies, I illustrate the progression of rural northern communities' vulnerability to spring floods, analyze causes and progression of the hazard (i.e., ice jam floods), and introduce an integrated approach to spring flood risk reduction in rural northern communities. Although I focus on ice jam flooding, a number of my findings are applicable to other types of disasters in the rural northern regions.

1.1 Dissertation Objectives

River ice thawing and breakup is an annual springtime phenomenon in the North. Depending on regional weather patterns and river morphology, breakups can result in floods (Beltaos, 2007). Breakup floods often cause catastrophic ice and water damage to exposed and vulnerable riverine communities, and lead to socioeconomic and ecological crisis (e.g., Beltaos, 1983; Gerard & Davar, 1995; Buzin, 2004; Pagneux, Gísladóttir, & Jónsdóttir, 2011; Kontar, Bhatt, Lindsey, Plumb, & Thoman, 2015; Gavrilyeva, Eichelberger, Kontar, Filippova, & Savvinova, in press; Kontar, Trainor, Gavrilyeva, Eichelberger, & Tananaev, in press).

Frequently resulting in severe damage to homes and infrastructure, destruction of livelihoods and services, ecological degradation, and negative health effects, ice-jam floods often lead to socioeconomic and ecological crisis in impacted communities (Beltaos, 1995; Buzin, 2004; Pagneux et al., 2011; Burrell et al., 2015). Although summary figures for the cost of ice jam flooding do not yet exist, Prowse et al. (2011) approximated the cost of annual ice-jam floods in North America to be 280 million dollars. Adverse ecological impacts of ice jam floods are indirect and commonly caused by spilled toxic and human waste (Scrimgeour, Prowse, Culp, & Chambers, 1994).

Breakup floods commonly originate upstream from ice jams – accumulations of chunks and sheets of ice in the river channel, that block or restrict stream flow during spring melting (Belore, Burrell, & Beltaos, 1990). Ice jams form anywhere in a river channel where its transport capacity is exceeded by obstructions, such as river bends or bridges (Beltaos, Miller, Burrell, & Sullivan, 2006). Once formed, ice jams produce rise of water levels of meters per day and can hold for days, forcing melt water and ice floes to back up for miles and cause flooding upstream. Sudden release of ice jams can also result in flash flooding downstream and cause additional damage by rapid withdrawal of water from flooded areas (Beltaos, 1995).

Spring flood risk is especially high in rural and remote communities, where flood relief and recovery are complicated by the region's unique geographical and climatological features, limited physical and communication infrastructure, and insufficient disaster mitigation and preparedness measures (Kontar et al., in press). To reduce flood risk, one needs to, foremost, accurately identify and assess it (UNISDR, 2015). A risk, in the context of this research, is the likelihood of an ice jam flood occurring and resulting in loss, injuries, damage and destruction in rural northern communities (Twigg, 2004; UNISDR, 2015).

Flood risk is the result of a complex interaction between a series of natural and human processes and events that generate conditions of hazard (i.e., ice jam floods), and a population's exposure and vulnerability (Figure 2.1) (Twigg, 2004; UNISDR, 2007; IPCC, 2012; Wisner et al., 2012). Understanding flood risk, therefore, requires understanding of a wide spectrum of natural and scientific processes – physical, climatological, political, economic, cultural, social, and psychological. Accurately identifying and assessing flood risk requires interdisciplinary research. Reducing flood risk requires interagency collaboration on top of that.

In other words, breakup floods are complex natural and social phenomena. Their scale, frequency, and impact can be effectively addressed only through holistic policy solutions, which are based on coherent science-based assessments (Boaz & Hayden, 2002; Cutter et al., 2015). Integrated flood risk reduction requires interdisciplinary research and interagency collaborations with a diverse group of stakeholders. Stakeholders involved in flood risk reduction include representatives from all levels of government, social and natural scientists, NGOs and other civil society organizations, private sector, and emergency, military and medical agencies, and the residents themselves (Kontar & Trainor, 2016; Gavrilyeva et al., in press; Kontar et al., in press).

Preliminary research has demonstrated that the disaster community described above is too fragmented to address flood risk in the Far North in a holistic manner. According to Twigg (2004) and Gall, Nguyen, and Cutter (2015), this fragmentation results from a lack of cross-disciplinary understanding, lack of dialogues among stakeholders, and a scientific culture of competiveness and professional jealousy, fueled by competition for funds. In this dissertation, I address the importance of an integrated flood risk reduction framework, and introduce disaster risk communication approaches that could enhance collaboration among the stakeholders.

With the main goal to identify best practices in spring flood risk reduction, I conducted a comparative analysis between two flood-prone communities in Alaska, United States and the Sakha Republic (Northeast Siberia), Russia. Via two case studies, I assessed each component of the flood risk, and analyzed existing practices in flood risk reduction. I pursued several specific research questions, outlined below.

Objective 1: To outline and assess the progression of rural northern communities' vulnerability to spring flood risk.

What vulnerability factors (i.e., root causes, dynamic pressures, and unsafe conditions), and their historic interrelation put rural northern communities at flood risk? What measures could reduce vulnerability? What are the obstacles to vulnerability reduction?

Objective 2: To outline and assess the causes and progression of ice jam floods.

What natural phenomena and processes cause ice jam floods and determine their locations, severity, and duration? Which mitigation and prevention measures could reduce the flood risk? What are the challenges and obstacles in ice jam mitigation and prevention measures?

Objective 3: To develop an integrated approach to spring flood risk reduction in the rural North.

What are the drawbacks in the existing disaster management approaches in the North? What key activities should be included in each phase of the disaster management cycle to reduce the risk of ice jam flood disasters in rural northern communities? What communication strategies could improve interagency collaboration during each phase of the flood risk reduction cycle?

1.2 Research Methods Overview

To answer the research questions outlined above, I conducted a comparative case study analysis between two flood-prone rural communities, Galena in Alaska, United States and Edeytsy in the Sakha Republic (Northeast Siberia), Russia (Figure 1.1). Comparative case studies entail the analysis of the similarities and/or differences across two or more cases that share a common focus (i.e. two communities under flood risk) (Baxter & Jack, 2008; Bhattacherjee, 2012).

Case study research is a method of in-depth studying of a phenomenon or a process over time within a bounded system (i.e., a community) (Bhattacherjee, 2012; Yin, 2012). Case study research has a long tradition in disaster research as it facilitates the discovery of cultural, political, and social factors relevant to the phenomenon of interest (Bhattacherjee, 2012; Phillips, 2014). In this way, case study research aids disaster scholars in identifying driving forces of disaster risk in a specific community.

Figure 1. 1 Research sites. Galena, Alaska, United States and Edeytsy, Sakha Republic, Russia (modified from Kontar et al., 2016).

Moreover, case study research allows scientists to employ multiple methods of data collection, thus facilitating evidence triangulation (i.e. establishing converging lines of evidence) and enhancing data credibility (Baxter & Jack, 2008; Bhattacherjee, 2012; Yin, 2012). It also allows studying the phenomenon of interest from the perspectives of multiple participants, and incorporating traditional vulnerable populations into studies (Bhattacherjee, 2012; Phillips, 2014). These particular features made case study methodology a useful fit for my research interest.

To identify and assess the three defining components of the flood risk in Galena and Edeytsy (i.e., hazard, exposure, and vulnerability) and best practices in spring flood risk reduction in both regions, a bilateral and multidisciplinary team of experts was assembled[2] (Kontar & Trainor, 2016; Gavrilyeva et al., in press; Kontar et al., in press). Specific points of comparison are outlined in Table 1.1.

Table 1. 1 Points of Comparison.

	Galena, Alaska	**Edeytsy, Sakha Republic**
Population size & demographics	467 (2015) vs. 477 (2013) → Native Alaskans (63.62%) → White (29.36%) → Other races (7.02%)	1,321 (2015) vs 1,505 (2013) → Native Sakha (99.99%)
Livelihood	Subsistence & cash economy	Cattle ranching & farming
Mean annual income (household)	$64,067	$22,036
Average damage caused by flood in May 2013	Good	Good
Flood awareness, monitoring, & warning	Good	Good
Flood preparedness	Poor	Good
Flood management	Reactive	Proactive
Flood governance	Decentralized	Centralized
Satisfaction ratings with flood management	Poor	Good

[2] The team was established as part of the US Department of State, US-Russia Peer-to-Peer Dialog Initiative. The project lasted from October 2015-September 2016.

The team consisted of US and Russian geoscientists, social scientists, students, emergency managers, and civil and tribal community leaders. This project was truly unique as there is little record in the disaster risk reduction literature of truly multi-stakeholder projects, which involved collaboration among local communities, scientists, local, regional, and national governments, and NGOs.

Each of the team participants represented a key stakeholder group that takes part in flood risk and crisis management in both countries, and shared his/her expertise with the relevant counterparts. Throughout the project, I systematically collected, analyzed, and synthesized the data, and outlined emerging concepts and patterns in flood risk reduction in Alaska and the Sakha Republic.

The team acquired data through a combination of surveys, focus groups, direct observations, and secondary data review. All project participants contributed to the design of the survey and focus group protocols. I archived and analyzed the data for the content of this dissertation, and conducted the secondary data analysis to fill in the data gaps. Collecting data from multiple sources allowed me to triangulate the evidence and thus arrive at robust findings (Baxter & Jack, 2008; Yin, 2012).

1.3 Research Sites

For the comparative case study analysis, I selected two flood-prone rural communities, Galena in Alaska, United States and Edeytsy in the Sakha Republic, Russia (Figure 1.1). Within a week of each other in May 2013, Galena and Edeytsy sustained major ice jam floods. In both communities, floodwaters and ice floes destroyed or severely damaged nearly all homes and key infrastructure and displaced hundreds of people (Figure 1) (Kontar & Trainor, 2016; Gavrilyeva et al., in press; Kontar et al., in press).

Figure 1. 2 Impacted Houses in Galena and Edeytsy. (left) Destroyed house in Galena after the flood in May 2013 (modified from Korta, 2016); (right) inundated house in Edeytsy in May 2013 (modified from Yadreev, 2015).

The time proximity between the two floods is the main reason why I selected Galena and Edeytsy as my research sites. With several residences remaining under reconstruction, the memories of the floods are still alive in both communities. Thus, they are at the same stage of recovery and have had the same amount of time to act on lessons from the disaster. Furthermore, both communities are prone to major spring floods. Historical flood records allowed me to identify driving forces of the flood risk in Galena and Edeytsy, and trace the transformation of flood risk reduction efforts in both regions.

Besides physical risk, another reason for my selection was the enthusiasm shown by the communities' leaders in flood risk reduction on the local level. Tribal and municipal leaders in Galena, and municipal leaders in Edeytsy have been actively pursuing flood mitigation opportunities (e.g., construction and reinforcement of dikes, partial relocation of population from the flood-zone, and raising buildings on pilings), and enhancing community flood awareness and preparedness plans.

The final reason for my research site selection is the interagency involvement in flood risk and crisis reduction efforts in Galena and Edeytsy. The 2013 floods caused multi-million dollar damages in both communities, impelling local administrations to call for state and federal disaster response and recovery funds. As a result, an array of stakeholders from governmental, non-governmental, public and private sectors were engaged in flood relief and recovery in both regions. For that reason, Galena and Edeytsy provided a great opportunity to compare and contrast collaboration and communication between the diverse stakeholders involved in disaster risk reduction in both regions.

1.3.1 Galena, Alaska

Galena is a remote community of 467 people, located in traditional Koyukon Athabascan Indian territory in central Alaska (U.S. Census Bureau, 2015). It is situated on the northern bank of the Yukon River, over 430 kilometers away from the nearest urban center in Fairbanks, and 1600 km from the State's capital, Juneau. As pointed out by Sprott (2000), Galena exhibits both unique and similar features to other rural Alaskan communities. The distinction is obvious in its population's size and proportion. Galena's population of over 450 people is larger than most villages, while the proportion of aboriginal population (slightly over 60%) to non-aboriginal is lower than in most villages (Table 1.1).

Unlike the majority of Alaskan villages, Galena is host to branches of a few federal and state agencies (e.g., U.S. Postal Service, and Alaska Department of Fish and Game), which increase and diversify employment opportunities. As underlined by L. Morgan (1972), employment has always been higher in Galena than in the average Alaskan village. Yet, Galena residents, similarly to the rest of rural Alaskans, largely practice a dual economy, and rely on subsistence foods as well as services, such as hunting and selling furs (Sprott, 2000; Pelkola & Korta, 2015). Galena also resembles other Alaskan villages in its remoteness and isolation. The community can be reliably accessed only via aircraft year around, snowmachines in the winter, and boats and barges in the summer (Taylor, Hum, & Kontar, 2016).

Despite the absence of road access, Galena contains infrastructure unmatched for a rural Alaskan community. In 1993, a U.S. Air Force (USAF) base was deactivated in Galena, and its entire infrastructure (except for the state owned airfield) was transferred to the village. The former airport base is the only part of Galena that is protected from breakup floods by a dike, which was constructed in 1945 (Kontar et al., 2015; Taylor et al., 2016). In 1997, USAF buildings were turned into classrooms and dormitories of the Galena Interior Learning Academy (GILA); the boarding school offers vocational training along with a standard academic curriculum to over 100 students from rural Alaska each year (GILA, n.d.). GILA also provides additional employment opportunities for Galena residents.

Due to its strategic geographic location and unmatched for a rural Alaskan community infrastructure, Galena is a regional transportation, economic, cultural, and educational hub for many rural communities in central Alaska (Sprott, 2000). If Galena fails to recover from a spring flood, this would lead to the demise of a network of communities in Interior Alaska (Kontar et al., 2015; Taylor et al., 2016).

The airfield and former airbase infrastructure are crucial during flood relief and recovery operations. During the 2013 flood, Galena residents took shelter in GILA's dorms, while emergency managers set up their camps on the only dry land behind the dike (Denver, 2016; Korta, 2016). The water-free airfield facilitated evacuations and transportation of emergency personnel and supplies to the impacted community. According to Denver (2016) and Korta (2016), the dike came very close to breeching during the flood in May 2013, and still needs to be repaired to sustain future floods. The village does not have enough funds to take up a million-dollar project, while the USAF no longer sees it as their responsibility (Korta, 2016).

In addition to the construction of the dike, spring flood mitigation and prevention measures in Galena's history included partial relocation and elevation of houses on steel pilings (Kontar et al., 2015; Taylor et al., 2016). After the ice jam flood in May 1971, a subdivision called New Town was constructed one mile upriver with the goal to relocate Galena residents on higher ground, further from the floodplain (Morgan, L., 1972; Sprott, 2000). New Town remained dry for over 40 years, which, according to Pelkola and Korta (2015), led to a false sense of security among the New Town residents.

The flood in May 2013 destroyed or severely damaged over 90 percent of the homes in New Town; most residents were caught off guard and unprepared for evacuation and further consequences. After the 2013 flood, as part of enhanced flood risk reduction, most houses in Galena were rebuilt on steel pilings (Denver, 2016; Korta, 2016). Old Town, the original Native settlement, is situated between the dike and the river, and thus remains exposed to floods.

Propelled by the need to work for wages at the ore mine in the current Galena location, the first permanent population settled in Old Town in 1920 (Arundale, 1985). Flood risk was not factored into the investment decisions during the initial settlement of Galena in its current floodplain location. People settled in log houses, which are easy to dismantle and dry out after the floods (Arundale, 1985; Sprott, 2000).

Establishment of the USAF base in Galena provided economic and political incentives for the community's expansion (Arundale, 1985; Sprott, 2000). As the community grew, so did its dependence on the life-sustaining infrastructure and housing. Continuing not to invest in flood risk reduction measures left Galena's residents and their assets exposed and vulnerable to breakup floods. The flood in May 2013 destroyed nearly all infrastructure and houses in Galena. In addition to their homes, hundreds of residents lost their livelihoods, and as a consequence remained in over a two-year-long evacuation (Pelkola & Korta, 2015). The recovery in Galena was also slowed by the community's remoteness and short rebuilding season (Kontar et al., 2015; Taylor et al., 2016).

The 2013 breakup floods caused over 70 million dollars of damage in rural Alaska, thus impelling local administrations to call for state and federal disaster response and recovery funds (Alaska Division of Homeland Security and Emergency Management [ADHSEM], 2015). As a result, an array of stakeholders from governmental, non-governmental and private sectors were engaged in flood relief and recovery (Table1.2) (Kontar & Trainor, 2016). Interagency response that proceeded sequentially rather than collaboratively in parallel led to significant delays in Galena's recovery (Kontar et al., 2015; Taylor et al., 2016).

Table 1. 2 Alaska Stakeholders. Key stakeholders involved in spring flood management in Interior Alaska.

Stakeholder	Role in Spring Flood Management
Federal Emergency Management Agency (FEMA)	A federal agency responsible for coordinating the response to a disaster that overwhelms local and state resources, and providing the necessary financial and technical assistance to impacted areas (FEMA, 2016a). FEMA provides financial means to impacted individuals and families through the allocation of individual assistance grants, and local and regional administration through the allocation of the public assistance grants.
National Weather Service (NWS)	Under the National Oceanic and Atmospheric Administration (NOAA), NWS is responsible for monitoring river ice conditions, providing flood forecasts, and warning at-risk communities and emergency managers (NWS, 2011; Plumb, 2015).
Alaska Division of Homeland Security and Emergency Management (ADHSEM)	A state agency responsible for coordinating response and providing a rapid recovery to Alaskan communities during disasters that overwhelm local resources (ADHSEM, n.d.; Denver, 2016).
Tanana Chiefs Conference (TCC)	A non-profit tribal consortium promoting health and wellbeing for Native communities and addressing the needs of the tribes during disasters. Although not a response agency, TCC coordinates with private, state, and federal agencies to provide the impacted populations with needed resources, e.g., housing and food, during and after the flood (TCC, n.d.).
American Red Cross of Alaska	A non-profit agency that collaborates with the State of Alaska, TCC, and local administration and provides relief to disaster victims and assist communities in emergency prevention, preparedness and response (Jackson, 2016).
Local & tribal governments	Various local and tribal agencies cooperate before, during and after the flood to assist residents with evacuations and property relocations, and coordinate with the state, federal, and non-profit agencies to facilitate disaster preparedness and relief.

1.3.2 Edeytsy, Sakha Republic

Edeytsy is a rural community of 1,261 people, located in central Sakha Republic in Northeast Siberia (Yadreev, 2016). As in most rural Sakha communities, Edeytsy's population is over 90 percent aboriginal (Table 1.1). Sakha language and customs are well preserved and practiced daily (Lindenau, 1983). Cattle ranching is the traditional means of livelihood in the Sakha Republic, and it is still largely practiced in rural communities (Lindenau, 1983; Vakhtin, 1992). As within most of rural Sakha, Edeytsy is a predominantly agricultural and cattle-ranching community. Similar to Galena, Edeytsy has supplementary livelihood opportunities, including employment at the local school, kindergarten, clinic, fire department, and post office (Yadreev, 2016).

Edeytsy is situated on the eastern bank of the Lena River, only 35 kilometers from the regional center Namtsy, and 60 kilometers from the Republic's capital of Yakutsk. Unlike Galena, Edeytsy can be reliably accessed year-round via road, thus facilitating flood relief and reconstruction efforts. Thereby, Edeytsy's key infrastructure was rebuilt in only six months after the flood in May 2013 (Yadreev, 2016).

Despite the quick response and relief efforts, the 2013 flood caused socio-economic crisis in Edeytsy. In two weeks, floodwaters inundated nearly all farms, shrinking arable land to 70 percent of pre-flood, and decreasing the growing season by one month. Consequently, the autumn harvest was low, and most residents incurred financial losses (Kontar, Eichelberger, Gavrilyeva, Filippova, & Savvinova, 2016; Yadreev, 2016).

Floodwater and ice debris also destroyed or severely damaged most of Edeytsy's homes and key infrastructure. The overall flood damages in Edeytsy reached over 10 million USD, and prompted the local administration to call for federal and republic flood relief and recovery funds.

The rapid six-month recovery in Edeytsy was facilitated through ongoing interagency communication and collaboration (Table 1.3) (Yadreev, 2016; Gavrilyeva et al., in press; Kontar et al., in press).

Table 1. 3 Sakha Stakeholders. Key stakeholders involved in spring flood management in Sakha Republic.

Stakeholder	Role in Spring Flood Management
Lena River Basin Water Management (LBWM)	A federal agency responsible for organization and coordination of breakup flood mitigation (e.g., ice cutting, dusting, and blasting) and relief efforts relative to federally owned infrastructure (Androsov, 2015).
Roshydromet - Russian Federal Service for Hydrometeorology and Environmental Monitoring	A federal agency responsible for flood hazard assessment, breakup and flood monitoring, flood forecasting and warning (Kusatov, 2015)
Ministry for Civil Defense, Emergencies and Elimination of Consequences of Natural Disasters (MChS)	A federal agency responsible for organization and coordination of preventative flood measures, response and recovery efforts, and damage assessment (Bykov, 2015).
Spring Flood Relief, Recovery, and Restoration Agency (FRRRA)	A state agency responsible for damage assessment, appointment for construction contracts, and compensation allocations (Androsov, 2015; Platonov, 2015).
Local governments	Various local agencies cooperate during floods with the goal to facilitate evacuations and allocation of compensations for damaged private property.

Greater losses in Edeytsy were avoided due to the timely relocation of cattle to higher ground. In the last six years, flood preparedness and early warning have significantly improved in Edeytsy. The precursor was the second largest breakup flood to date in May 2010, which killed cattle, and thus left the residents without their primary means of livelihood (Yadreev, 2016). Reports indicate no loss of cattle in the 2013 flood (Gavrilyeva et al., in press).

Similarly to Galena, flood risk was not factored into the investment decisions during the initial settlement of Edeytsy in their current floodplain location. Prior to the late 1920s, Sakha people were nomadic and lived in groups that rarely exceeded 30 people. According to the 1926 census, there were over 11 thousand rural settlements in Sakha with a mean population of 23.3 (Argunov, 1985). Similarly to Koyukon Athabascans, Native Sakha followed the seasons by migrating between their winter and summer camps and therefore were not at risk from breakup floods (Lindenau, 1983; Vakhtin, 1992).

Edeytsy, as a municipality, was formed in 1930 by the Soviet government (Old Sakha, n.d.). Establishment of the Soviet regime and collectivization[3] throughout the Sakha lands co-occurred with forced settlements of populations into permanent locations (Argunov, 1985). Several Native groups were integrated into Edeytsy to advance local kolkhozy[4]. Edeytsy was settled on the river to facilitate irrigation and water supplies for large cattle herds. The initial flood risk has amplified over decades due to the river channel migration and population increase (Gavrilyeva et al., in press). In surveys, Edeytsy residents noted the following flood years: 1968, 1978, 1997, 2007, 2009, 2010, 2011, and 2013 (Gavrilyeva et al., in press; Kontar et al., in press).

To minimize flood risk, a range of flood risk reduction measures have been implemented in Edeytsy with varying degree of success. A combination of structural and nonstructural mitigation efforts were implemented prior to and after the flood in May 2013. With financial support from the State (Republic) government, the construction of a dike was initiated after the breakup flood in May 2010 (the second largest flood on record). Due to incremental funding, construction of the dike was not completed prior to the flood in May 2013; construction is still ongoing (Yadreev, 2016). After the 2013 flood, a few residences and key public buildings (e.g., school, kindergarten, clinic, and office of the local administration) were elevated.

Edeytsy, as most rural riverine Sakha communities, relies predominantly on mechanical ice jam prevention and removal measures. When dangerous ice jams form, a series of ice

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[3] *Collectivization* was a policy of forced consolidation of individual peasant households into collective farms called "kolkhozes" as carried out by the Soviet government in the late 1920's - early 1930's (Osofsky, 1974).

[4] *Kolkhoz* (pl. kolkhozy) is a collective farm in the former Soviet Union. It was operated on state-owned land by peasants from a number of households who were paid as salaried employees on the basis of quality and quantity of labor contributed (Osofsky, 1974).

dusting, cutting, and blasting operations take place (Androsov, 2015; Bykov, 2015; Platonov, 2015). Although ice jam prevention and removal measures are regularly implemented, there is no statistical evidence of their effectiveness. Mechanical ice jam mitigation measures are designed according to hydrological models developed by scientists. However, no criteria for the effectiveness of these models have yet been established. Therefore, there is no published evidence of these methods' effectiveness.

2. Interdisciplinary Literature Review and Framework Analysis

As with any natural disaster, understanding spring floods requires an understanding of a wide spectrum of natural and social phenomena (Twigg, 2004; Wisner et al., 2012; UNISDR, 2015). A large number of academic disciplines – including but not limited to hydrology, climatology, anthropology, economics, communication, and political sciences – have applied their concepts to various aspects of disaster risk reduction. Theories and frameworks help to organize this mass of related and yet diverse information into scenarios that are easy to communicate to legislators, the population at-risk, and peers from other disciplines (Wisner et al., 2012).

2.1 Literature Review Strategy

I researched a number of databases to locate published academic literature and disaster practitioners' reports for the review: eLIBRARY.ru; Elmer E. Rasmuson Library; ELSEVIER Journals Online; EM-DAT; Google Scholar; MünichRe; SAGE Journals Online; Scholar.ru; Springer Journals Online; Taylor & Francis Online; the Web of Science; and Wiley Online Library. In addition, four journals were extensively hand-searched for relevant articles: International Journal of Disaster Risk Reduction; Journal of Public Relations Research; Natural Hazards Journal; and Risk Analysis: International Journal. I consulted the reference lists of documents retrieved from these sources to identify additional publications.

I identified conference presentations, technical documents, and other types of grey literature through general internet searches, as well as targeted searches of the websites of the: Colorado Natural Hazards Center; FEMA; IFRC; LBWA; MChS; NWS; the United Nations Office for Disaster Risk Reduction (UNISDR); and the World Health Organization (WHO). I consulted the reference lists of documents retrieved from all of these sources to identify additional key publications, and thereby complete the data bank for this review.

The search terms used to locate the literature for my research included, but were not restricted to: disaster risk reduction/disaster risk management AND Arctic/Circumpolar North/North; disaster risk reduction/disaster risk management AND floods/inland flooding; disaster risk reduction/disaster risk management AND lesson/best practice/guidance; disaster risk reduction/disaster risk management AND communication/risk communication; risk communication AND natural disaster/natural hazards; risk/disaster communication AND rural communities; ice jam/breakup/spring floods AND risk reduction AND lesson/best practice/guidance; ice jam/breakup/spring floods AND mitigation AND lesson/best practice/guidance; ice jam/breakup/spring floods AND United States/Russia.

While conducting this review, I focused on retrieving documents in English and Russian languages, which were published between January 1940 and March 2017. Although my dissertation and this review concentrated on examples of spring flood risk reduction from Alaska, United States, and the Sakha Republic, Russia, no geographic restrictions were placed on the literature search. Using QSR NVivo, I organized analyzed and coded selected documents thematically.

2.2 Disaster Risk

To reduce disaster risk, one needs to, foremost, accurately identify and assess it. A risk, in disaster context, is the likelihood of a specific hazard occurring and resulting in loss, injuries, damage and destruction from a disaster (Twigg, 2004; UNISDR, 2015). Today, disaster risk is widely recognized as the result of a complex interaction between a series of natural and human processes and events that generate conditions of hazard, exposure, and vulnerability (Figure 2.1)

(Twigg, 2004; UNISDR, 2007; IPCC, 2012; Wisner et al., 2012). Simply put, disaster risk is generated through an exposure of a vulnerable community to a hazard.

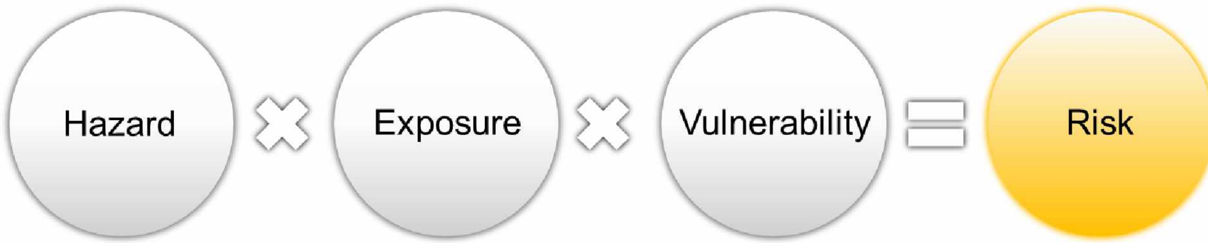

Figure 2. 1 Disaster Risk Components. Disaster *risk* is a combination of the severity and frequency of a *hazard*, the number of people and assets *exposed* to the hazard, and their *vulnerability* to damage. Note: this formula definition should be regarded as a mnemonic device, not a mathematical equation. Modified from UNISDR, 2007 and Wisner et al., 2012.

Four decades of academic literature and practitioners' reports on disasters have demonstrated that disasters are indicators of development failures, unstable economic and social processes, and poorly adapted societies (e.g., Baird, O'Keefe, Westgate, & Wisner, 1975; Anderson & Woodrow, 1989; Maskrey, 1989; Oliver-Smith & Varley, 1994; Heijmans & Victoria, 2001; Hyogo Framework for Action [HFA], 2005; Cutter et al., 2015). Three key components of disaster risk – hazard, exposure, and vulnerability – are influenced by a number of risk drivers, such as poorly planned and managed regional development, population marginalization and poverty, and climate change (only some) and environmental degradation (Wisner, Blaikie, Cannon, & Davis, 2004; UNISDR, 2015).

Disaster researchers and practitioners recognize that risk is dynamic, in the sense that it changes rapidly as a result of evolving hazards, exposure and vulnerability (Wisner et al., 2004; IPCC 2012; Global Facility for Disaster Reduction and Recovery [GFDRR], 2014). Therefore, they advise decision makers to prepare for the immediate as well as future risks (GFDRR, 2014; Cutter et al., 2015; UNISDR, 2015).

To identify and estimate possible social and economic impacts from disasters, researchers and practitioners conduct risk assessments. The World Bank outlined five key areas in which accurate risk assessment aids decision-making, first in *The Sendai Report: Managing Disaster Risks for a Resilient Future* (Sendai Report, 2012) and later in *The Understanding Risk in an Evolving World Report* (GFDRR, 2014). These areas include risk identification, risk reduction, disaster preparedness, financial protection, and resilience construction (Table 2.1).

Table 2. 1 Risk Assessment in Decision-Making. Examples of risk assessment application in decision-making. Modified from Sendai Report, 2012 and GFDRR, 2014.

Decision-making	Examples of Application
Risk Identification	→ Understanding, communicating, and raising awareness about disaster risk.
Risk Reduction	→ Informing policies, investments, and measures to reduce risk.
Disaster Preparedness	→ Informing early warning systems and emergency measures. → Supporting community preparedness and contingency planning.
Financial Protection	→ Developing financial applications to manage and/or transfer risk.
Resilient Reconstruction	→ Informing early and rapid estimates of damage. → Providing critical information for reconstruction.

To assist decision-making in regard to disaster risk reduction and disaster risk management, researchers and practitioners often see risk analysis as an interpretation of all types of data on hazards, vulnerabilities, and capacities (Twigg, 2004). No single formula or scenario for a comprehensive risk assessment exists due to the specifics of individual disasters (e.g., limited or restricted data access and lack of historical records). Yet, the key components of a risk assessment include hazard, exposure, vulnerability, impact, and risk (Figure 2.2) (Sendai Report, 2012; GFDRR, 2014). Since risk assessment entails the gathering and analysis of diverse data, it requires multi-institutional and interagency collaborations (Gaillard & Mercer, 2012; GFDRR, 2014).

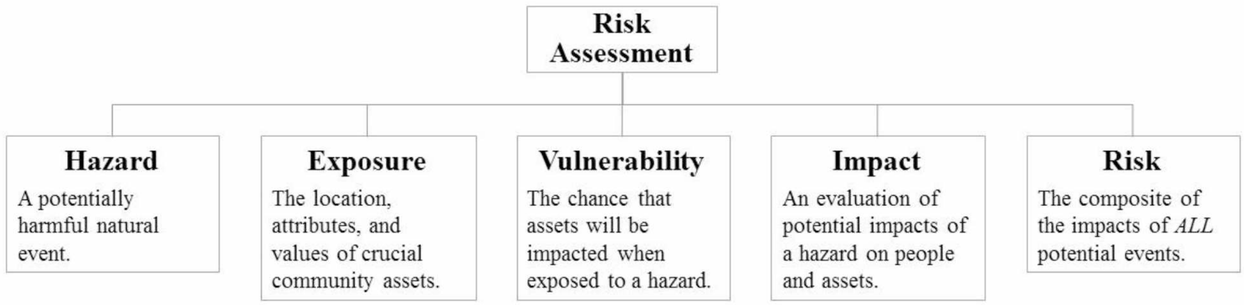

Figure 2. 2 Risk Assessment. Key risk assessment components in the context of natural disasters. Modified from Sendai Report, 2012 and GFDRR, 2014.

2.2.1 Natural Hazards and Unnatural Disasters

Hazard is a defining component of disaster risk (Figure 2.1) (Blaikie, Cannon, Davis, & Wisner, 1994; Twigg, 2004; Wisner et al., 2012; UNISDR, 2015). To sum up common definitions, a hazard is a physical phenomenon, technological accident, or a human activity that could potentially cause a severe threat to humans and their welfare (Twigg, 2004; UNISDR, 2007; Hansford, 2011; GFDRR, 2014). In the context of this research, a hazard is regarded as a potentially harmful natural event (i.e., spring flood) that may result in loss of life, injuries and other health impacts, damage and destruction of infrastructure and private property, social and economic disruption, and environmental degradation (UNISDR, 2007; IPCC, 2014).

Although frequently used interchangeably, natural hazards and natural disasters are not synonyms. Moreover, many scientists object to the combination of the words natural disasters (e.g., Ball, 1975; O'Keefe, Westgate, & Wisner, 1976; Blaikie et al., 1994; Wisner et al., 2004; Kelman, 2010; Gaillard et al., 2014; Cutter et al., 2015). They argue that there is no such thing as natural disasters, but disasters often follow a natural hazard. Regardless, the term itself is universal and understood among disaster scholars.

The connotation that disasters are caused by nature prevailed around the world (even among disaster scholars) until the mid-1940s. It took origin from many belief systems (including Western thought) that deities often punished humanity or asserted power through disasters

(Kelman, 2010). Although scholars and philosophers (e.g. Rousseau and Voltaire, 1756, as cited in Kelman, 2010) have been questioning the standard view of disasters as being natural or deific, the human factor was officially introduced in the disaster research only in the mid 1940s by Gilbert White, a pioneering disaster geographer.

In his doctoral research, G. White (1945) argued that it is as equally important to consider people's exposure to a disaster, as its triggering agent (i.e., a natural hazard). With the primary research focus on floods, he suggested a range of "adjustments" to human behavior that could reduce flood damage. Three decades later, Ball (1975) extended the human factor discussion to all natural hazards, and introduced disaster's inevitability as "the myth of the natural disaster."

A year later, O'Keefe et al. (1976) introduced the concept of vulnerability to the natural hazards and disaster discourse, and stressed that "the growing vulnerability of the population to extreme physical events," not natural events, as the key cause of increase in damage caused by disasters. The authors argued that socio-economic conditions of at-risk populations are principal factors in the severity of disasters. Negative impacts of disasters, such as fatalities, increase as people's vulnerability increases (O'Keefe et al, 1976).

The threefold focus of disasters on hazard, exposure, and vulnerability was further embedded in disaster literature by advanced and internationally renowned research in the fields of environmental geography, and human and political ecology by Oliver-Smith, 1986; Blaikie et al., 1994; Hewitt, 1997; Lewis, 1999; Mileti, 1999; Steinberg, 2000; Smith, N., 2005; Wisner et al., 2012; Cutter et al., 2015 (not exhaustive, only illustrative).

Although population's exposure and vulnerability significantly increase the negative impacts of disasters, the intensity of a hazardous event still plays a key role in the severity of disasters. Therefore, hazard assessment is a crucial fundamental factor in the overall disaster risk assessment and the consequent disaster risk reduction (GFDRR, 2014). Hazard assessment helps researchers and practitioners to identify the natural threats and understand their origins and behaviors, and therefore plan and prepare for potential disasters (Twigg, 2004; Hansford, 2011).

Hazard assessment begins with identification of natural hazards. Classifications of hazards vary across the disciplines and institutions, but generally include the following groups: geological or geophysical hazards, hydro-meteorological and climatological, biological and ecological hazards, and astronomical (Table 2.2) (Twigg, 2004; UNISDR, 2007; Wisner et al., 2012).

Table 2. 2 Origins of Natural Hazards. Classification of natural hazards into categories of their origins (Note: * not a comprehensive, but illustrative list).

Hazard Category	Hazards Origin	Phenomena/Examples*
Geological/geophysical	Hazards that originate as a result of geological, geomorphological, geophysical, geotechnical, and hydrogeological processes.	→ Earthquakes → Downslope hazards (e.g., landslides, mudslides) → Volcanic activity/emissions
Hydro-meteorological and climatological	Hazards that originate as a result of atmospheric, hydrological, and oceanographic natural processes.	→ Floods → Tropical cyclones and severe storms → Drought and desertification → Wildland fires → Permafrost thawing → Climate change and temperature extremes
Biological and ecological	Hazards that originate from living organisms and ecosystems.	→ Epidemic diseases, plant/animal contagion, extensive infestations → Deforestation and land degradation
Astronomical/ extraterrestrial	Hazards that originate outside the Earth.	→ Bolide airburst, impact events → Geomagnetic storms

Disaster scholars and practitioners also characterize natural hazards according to their magnitude and intensity, as well as temporal characteristics (e.g., speed of onset and decay, duration, and frequency), and the area they cover (Hansford, 2011; Wisner et al., 2012). These characteristics are integral components of hazard assessments. They provide accurate evaluations of the disaster risks faced by communities, and therefore help determine communities' capability to withstand these risks (Twigg, 2004; Hansford, 2011).

Natural hazards often trigger secondary and multiple cascading hazards, and cause technological as well as physical crisis. For example, the earthquake-tsunami-nuclear crisis (i.e., Fukushima Daiichi nuclear disaster) devastated Tōhoku, Japan in March 2011 (Hirose, 2016). Examples of secondary hazards caused by breakup floods include riverbank erosion, and chemical and bacterial contamination of water and soil (i.e., Galena and Edeytsy) (Prowse, 1995; Kontar et al., 2016; Gavrilyeva et al., in press). Although people cannot prevent natural hazards from occurring, they can mitigate and eliminate cascading hazards and other disastrous impacts through disaster risk reduction policies and actions (UNISDR, 2009; Cutter et al., 2015).

2.2.2 Exposure

Exposure is the second defining component of disaster risk (Figure 2.1) (GFDRR, 2014; UNISDR, 2015). It refers to the presence and number of people along with their environmental and economic resources, and social and cultural assets in at-risk locations (UNISDR, 2007; GFDRR, 2014; IPCC, 2014). If no individuals or assets are exposed to a hazard during its occurrence, then there is no risk, and subsequently no disaster.

Key exposure drivers include population growth, urbanization, migration, economic development, and cultural or religious heritage (Hansford, 2011; GFDRR, 2014; UNISDR, 2015). For instance, the rapid urbanization of the past six decades is characterized by dense populations living in poorly constructed houses in hazard-prone areas (Figure 2.3) (United Nations Department of Economic and Social Affairs, Population Division [UN], 2014; Cutter et al., 2015). Simultaneously, world trends for the past 40 years demonstrate a continuous increase of capital flow into hazard-prone areas, and simultaneously an increase in disasters caused by natural events (Figures 2.4, 2.5) (Cutter et al., 2015; Münchener Rückversicherungs-Gesellschaft [MünichRe], 2016). If these trends continue, the global average annual loss is estimated to increase to 415 billion dollars in the next 15 years (HFA, 2005).

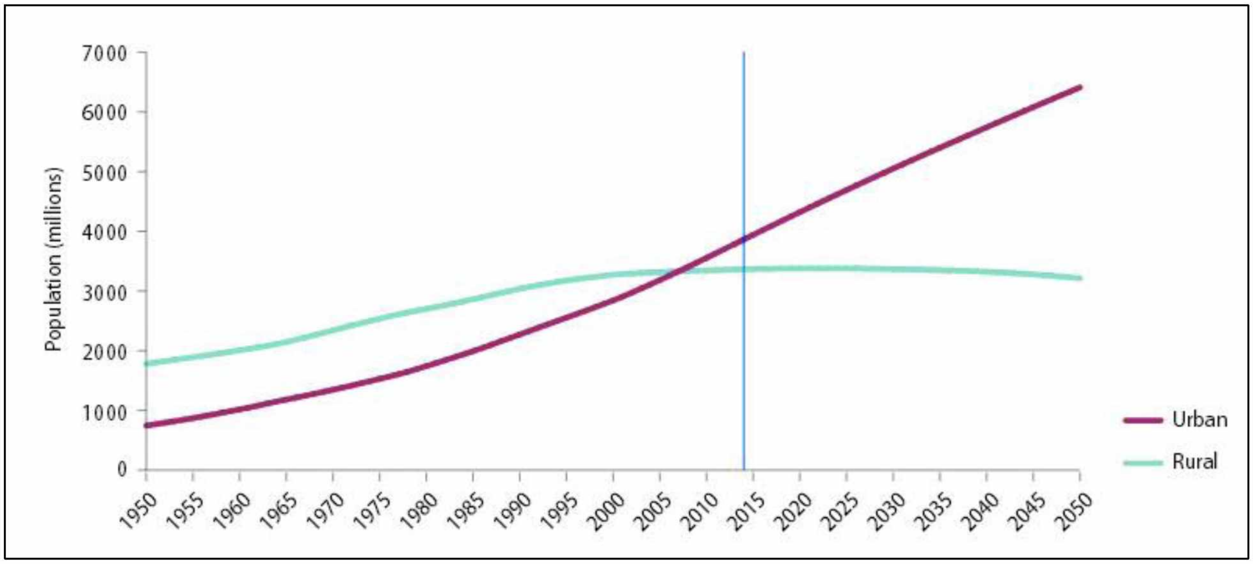

Figure 2. 3 Projection of the Increase of the Urban Population by 2050. Today, a majority of the world's population already lives in urban areas. Modified from UN, 2014.

Growth in exposure is one of the principal drivers of increasing disaster risk. At the same time, exposed communities and individuals face disaster risk only to the extent of their vulnerability (IPCC, 2012; UNISDR, 2015). While everyone in a community could be exposed to a hazard, not everyone would be vulnerable. Disaster research over the past three decades has revealed that the poor and marginalized members of society suffer disasters worst and more frequently (Beck, 1992; Twigg, 2004; UNISDR, 2009; Wisner et al., 2012). In his theory of Risk Society, a renowned contemporary sociologist and theorist Ulrich Beck (1992) demonstrated the history of risk distribution, and argues that risks, like wealth, adhere to the class pattern, only inversely. Beck (1992) argued that poverty makes people vulnerable to risks, while wealth and power can reduce risks.

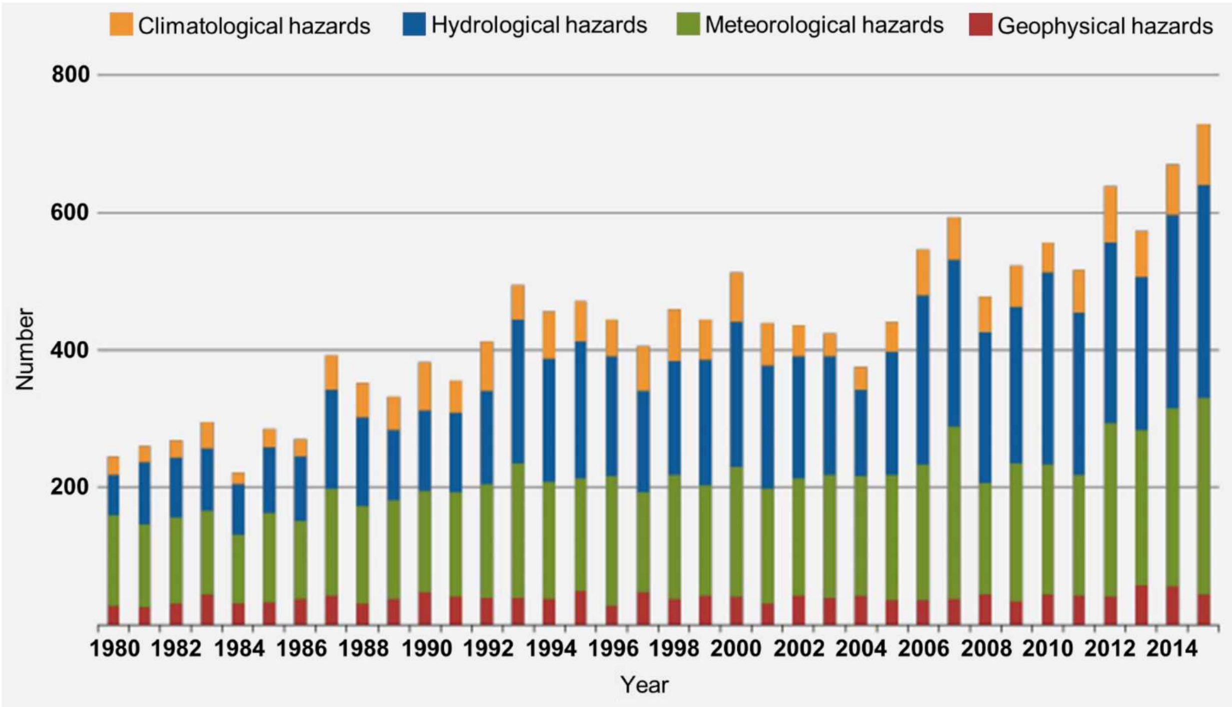

Figure 2. 4 Disaster Events, 1980-2015. The number of disasters caused by natural events has more than doubled since 1980. Modified from MünichRe, 2016.

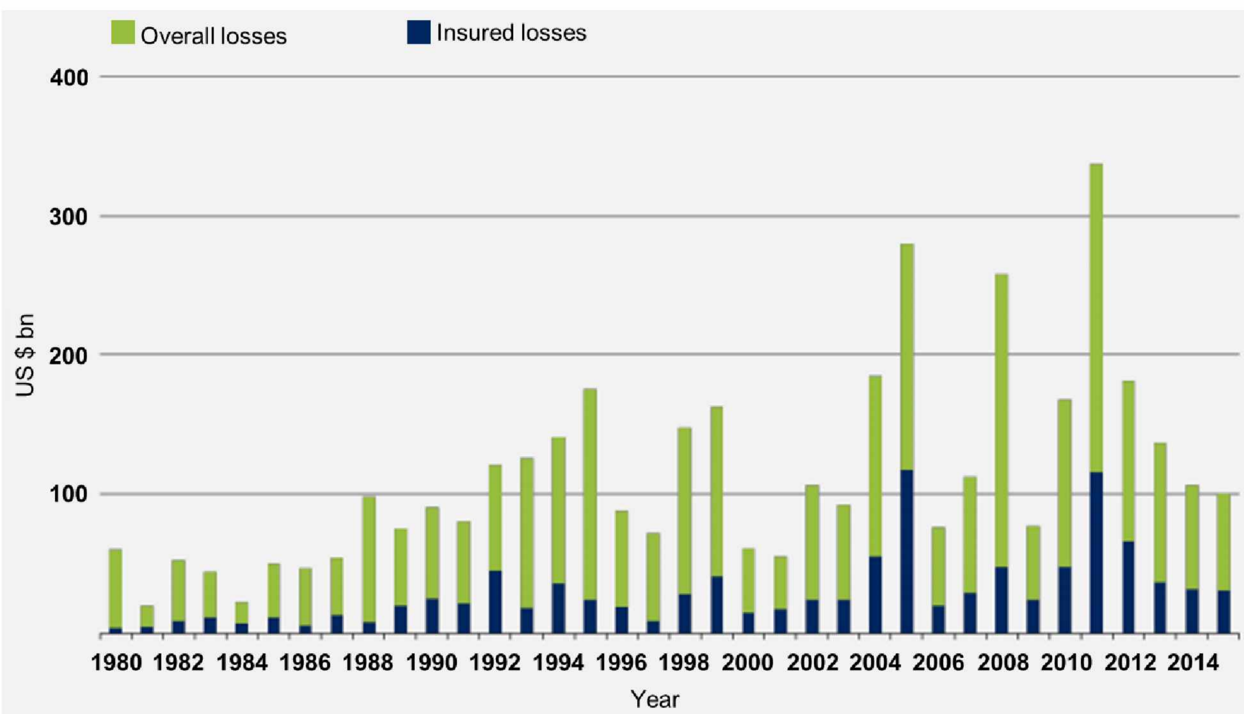

Figure 2. 5 Disaster Losses, 1980-2015. Overall and insured losses have been increasing steadily since 1980, reaching an annual average of 200 billion dollars in 2012. Modified from MünichRe, 2016.

2.2.3 Vulnerability

Vulnerability is the third defining component of disaster risk (Figure 2.1) (Cutter, 2013; GFDRR, 2014; UNISDR, 2015). Analogous to the terms risk and hazard, many definitions and interpretations of vulnerability exist in academic and professional literature (e.g., Alwang, Siegel, & Jorgensen, 2001; UNISDR, 2007; IPCC, 2014; IFRC, 2016a; World Health Organization [WHO], 2016). To summarize the most common definitions, vulnerability represents the characteristics and circumstances of a community that make it susceptible to the adverse impacts of a hazard.

Despite varying interpretations of its meaning, most scholars and disaster practitioners agree that vulnerability is the human dimension of disaster, and is the result of the range of economic, political, institutional, social, and psychological factors that shape communities (Table 2.3) (e.g., O'Keefe et al., 1976; Hewitt, 1983; Blaikie et al., 1994; Füssel, 2007; UNISDR, 2007; Mustafa, Ahmed, Saroch, & Bell, 2011; GFDRR, 2014; Cutter et al., 2015). In addition, vulnerability also relates to the wider environmental conditions that limit a community's ability to cope with the adverse impacts of hazards (Table 2.3) (Birkmann, 2006; IPCC, 2012). A population at risk can experience multiple vulnerability factors at the same time.

Table 2. 3 Vulnerability factors. Examples of physical, economic, environmental, political, and social vulnerability factors. (Note: * not a comprehensive, but illustrative list).

Vulnerability factors	Examples *
Economic factors	Lack of insurance, dependence on a single industry, and vulnerable rural neighborhoods, etc.
Environmental factors	Climate change, poor environmental management, and overconsumption of natural resources, etc.
Institutional and political factors	Lack of or inadequate disaster risk and crisis reduction policies, etc.
Physical factors	Hazardous location, lack of critical infrastructure, poor design and construction of buildings, etc.
Social factors	Poverty, marginalization, social exclusion, and discrimination by age, gender, disability, and social status, etc.

Vulnerability is a multidimensional and dynamic phenomenon, which is driven by diverse biophysical and socioeconomic processes from local and global levels (Blaikie et al., 1994; Adger, 2006; Wisner et al., 2012). Moreover, vulnerability factors are not always immediately obvious. For this reason, there may be groups or individuals (e.g., children, elders, and the disabled) within the same community that are more susceptible to disasters than the rest, but their vulnerability is not accounted for in disaster preparedness and contingency planning (Wisner et al., 2004; Cutter, 2013).

Due to its complexity, there is no single method for assessing vulnerability. Adger (2006) reviewed vulnerability research traditions, and concluded that researchers have struggled to develop robust and credible measures for vulnerability. Due to its multidimensionality, vulnerability cannot be reduced to a single metric and thus cannot be easily quantified (Alwang et al., 2001; Adger, 2006). For that reason, vulnerability analysis is predominantly qualitative.

Significant advances in vulnerability analysis were made by Blaikie et al. (1994) and Wisner et al. (2004) with the development of the Pressure and Release (PAR) disaster model – also known as the disaster Crunch Model. The PAR model helps researchers and practitioners to identify root causes or key drivers of vulnerability, as well as deficiencies in a community's capacity to cope and recover from disasters (Alwang et al., 2001).

The PAR model further validates the "unnatural disasters" framework (i.e., vulnerability paradigm) by stating that the level of disaster risk depends on the magnitude of hazards as well as the degree of an exposed population's vulnerability (Figure 2.6) (Blaikie et al., 1994). Blaikie et al (1994) further explained that a population is vulnerable when it is unable to adequately anticipate, withstand, and recover from a disaster. At the same time, a natural hazard by itself is not a disaster. A population, even if vulnerable for an extended time, will not experience a disaster without a triggering event (i.e., spring flood).

The PAR model helps to trace the connections between the impact of a hazard on an exposed population and a series of social, economic, political, and cultural factors and processes that constitute that population's vulnerability's progression. The progression of vulnerability, introduced by Blaikie et al. (1994) and expanded upon by Wisner et al. (2004), provides an explanation for the interrelations between vulnerability factors (Figure 2.6).Three key groups of processes that cause vulnerability include root causes, dynamic pressures, and unsafe conditions.

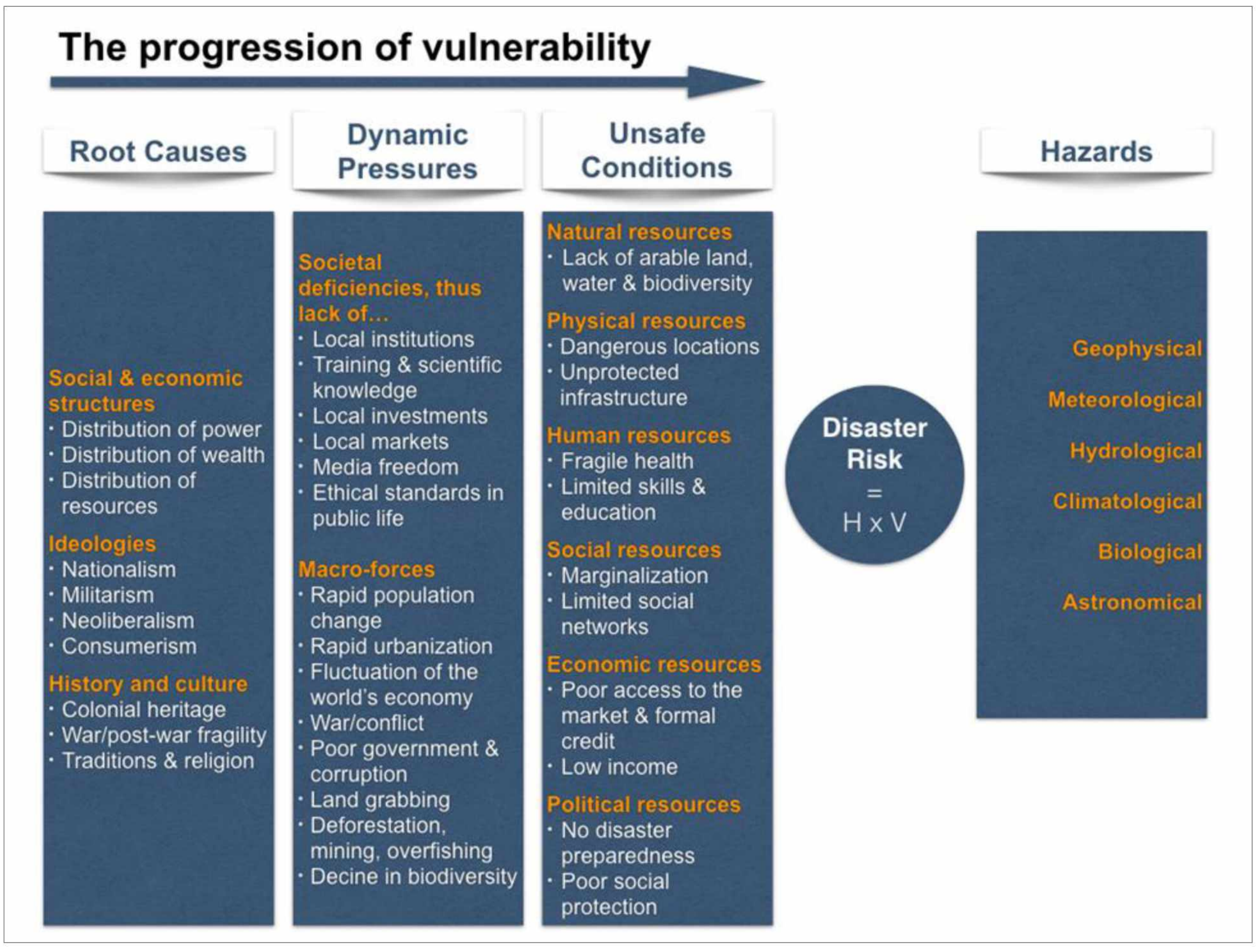

Figure 2. 6 The Pressure and Release (PAR) Disaster Model. Note: H – hazard; V – vulnerability. Modified from Blaikie et al., 1994.

Examples of the root causes include economic, demographic, and political processes, which determine distribution of and access to critical resources, wealth, and power within a community. Root causes usually arise in the past and in a distant center of economic or political power (Blaikie et al., 1994). The dynamic pressures category encompasses processes that transform the impacts of the root causes both temporally and spatially into unsafe conditions (Blaikie et al., 1994). Examples of dynamic pressures include rapid urbanization or migration that change the social structure. Finally, the unsafe conditions arise in a specific form of a population's vulnerability, such as living in hazard-prone locations in poorly constructed houses, or lacking disaster preparedness skills (Blaikie et al., 1994). Unsafe conditions are expressed in temporal and spatial dimensions (Wisner et al., 2004).

In summary, the PAR model shows that vulnerability (or *pressure*) is rooted in socio-economic and political processes (Figure 2.6). It is built up over time (years, decades, and centuries), and needs to be *released* to reduce the risk of disaster (Blaikie et al., 1994; Wisner et al. 2004). As outlined by Turner et al. (2003), the model directs attention to the conditions that make a population's exposure to a hazard unsafe, leading to vulnerability and to the causes that have created these conditions.

The deep analysis of the underlying driving forces of vulnerability made the PAR model one of the best known and frequently implemented tools for vulnerability assessment (Birkmann, 2006; Füssel, 2007). Since its emergence as a key part of a classic disaster risk treatise *At Risk* (Blaikie et al., 1994), the PAR model has been implemented by researchers and disaster practitioners worldwide to trace and analyze vulnerability causes of people and communities facing immediate and future risks (e.g., IFRC, 2006; Tsasis & Nirupama, 2008; Yasir, 2009; IPCC, 2012; Martin, Lewis, & Morain-Martin, 2012; Singh, 2014). Analysis of multiple case studies showed that the PAR model has been used chiefly to address social groups at risk that are distinguished by their class or ethnicity (Turner et al., 2003).

Despite its worldwide recognition, the PAR model has limitations. Foremost, the model cannot be applied operationally without an extensive collection and analysis of data (Birkmann, 2006). The data collection is complicated by the dynamic environments of vulnerability and hazards. Elements on both sides of the PAR framework spectrum are subject to constant change. The co-creators of the PAR model Wisner et al. (2004) stressed that in such a dynamic environment it is often difficult to distinguish the influence between dynamic pressures on unsafe conditions from the impact of root causes on dynamic pressures.

Turner et al. (2003) criticized the PAR model for not being sufficiently comprehensive for the broader concerns of sustainability science. According to their critique, the PAR model does not consider the vulnerability of biophysical systems within the human-environment interaction, nor does it emphasize the feedback received beyond the system under consideration (Kasperson et al., 1998 as cited in Turner et al., 2003).

Almost a decade later, Hai and Smyth (2012) criticized the PAR model for not emphasizing the gender aspects of vulnerability. The authors stressed that men and women are impacted by and recover from disasters differently due to the different roles, responsibilities, and access to resources they possess in their communities. Therefore, in the face of disaster, women experience gender specific vulnerabilities (Hai & Smyth, 2012). The authors suggested making the model more gender sensitive by examining the gender aspects of root causes, dynamic pressures, and unsafe conditions.

Birkmann (2006) pointed out that another limitation of the PAR model is its heavy emphasis on the national and global levels when it comes to vulnerability reduction. According to Birkmann (2006), the model implies that the only effective method to reduce vulnerability and risk is to change two root causes: political and economic systems. In this way, the PAR framework puts immense emphasis on the global and national levels despite the fact that many dynamic pressures and unsafe conditions might also be rooted by local conditions.

Despite its limitations, the PAR model is an important and effective approach for analyzing vulnerability and identifying its driving forces. The PAR model is an effective tool for explaining the vulnerability of a population, especially for the first time. In the context of this research, the PAR model is implemented to identify the driving forces of the vulnerability of residents in two research sites: Galena in Alaska, United States and Edeytsy in Sakha Republic, Russia (Figure 1.1).

2.3 Disaster Risk Reduction and Disaster Risk Management

Although often used interchangeably, there is a key distinction between the terms disaster risk reduction and disaster risk management. While disaster risk reduction is the policy objective of anticipating and reducing disaster risk, disaster risk management implies specific means and actions necessary to achieve the objectives of reducing risk (HFA, 2005; UNISDR, 2015). In other words, disaster risk management is the implementation of disaster risk reduction.

The foregoing context has characterized disaster risk as an indicator of poor or skewed development. Therefore, reducing disaster risk entails integrating disaster risk reduction policies and disaster risk management practices into the overall sustainable goals of a community (region or nation) (IPCC, 2012; Cutter et al., 2015; Sendai Framework for Disaster Risk Reduction [Sendai Framework], 2015). Involvement from all parts of society, including government, NGOs, professional and private sectors, is necessary for these initiatives to have a long-term effect (IFRC, 2000; Twigg, 2004; HFA, 2005; Cutter, 2013; UNISDR, 2015).

Altogether, disaster risk management strategies are forward-looking and are aimed at reducing or preventing the adverse impacts of likely, imminent or current hazard events. Today, the disaster research community largely agrees that upfront investments in hazard preparedness and mitigation will pay off in the long-run by reducing or even eliminating the negative impacts of disasters (e.g., HFA, 2005; Ismail-Zadeh & Takeuchi, 2007; Kelman, 2010; Gaillard & Mercer, 2012; Cutter et al., 2015; UNISDR, 2015; Zweynert, 2017). According to Ismail-Zadeh and Takeuchi (2007), spending from 5-10 % of the funds directed towards disaster recovery on mitigation would be enough to save lives and resources. For example, the estimated cost of protecting New Orleans, Louisiana against hurricane storm surges by reinforcing the levees would have cost 14 billion dollars. The total losses from Hurricane Katrina accumulated to 125 billion dollars (Ismail-Zadeh & Takeuchi, 2007).

Over the last decade, significant progress has been reported in disaster preparedness, response, and early warning (Sendai Framework, 2015). However, the progress in managing underlying risks of disasters has been limited worldwide (Zweynert, 2017). Although scholars argue that it is more reasonable to prevent losses than to rebuild after disasters, the existing disaster policies are predominantly reactive. Palmer (2013) and Cutter et al. (2015) explained this phenomenon with the fact that “hazard mitigation is not a vote-winner.” It is more politically advantageous to respond to disasters when constituents are asking for help. As a result, disaster policies, which are predominantly focused on response and recovery measures, prevail internationally.

As discussed previously, disaster risk results from the complex interactions between a series of natural and human processes and events that generate conditions of hazard, exposure, and vulnerability (Figure 2.1) (Twigg, 2004; UNISDR, 2007; IPCC, 2012; Wisner et al., 2012).

Disaster risk, therefore, can be reduced by managing the aforementioned conditions (GFDRR, 2014; Cutter et al., 2015; Sendai Framework, 2015). Reducing exposure and vulnerability requires accurate identification, assessment, and reduction of their driving forces. Hence, the hazard and vulnerability analyses discussed above play a crucial role in the design and implementation of disaster risk reduction strategies.

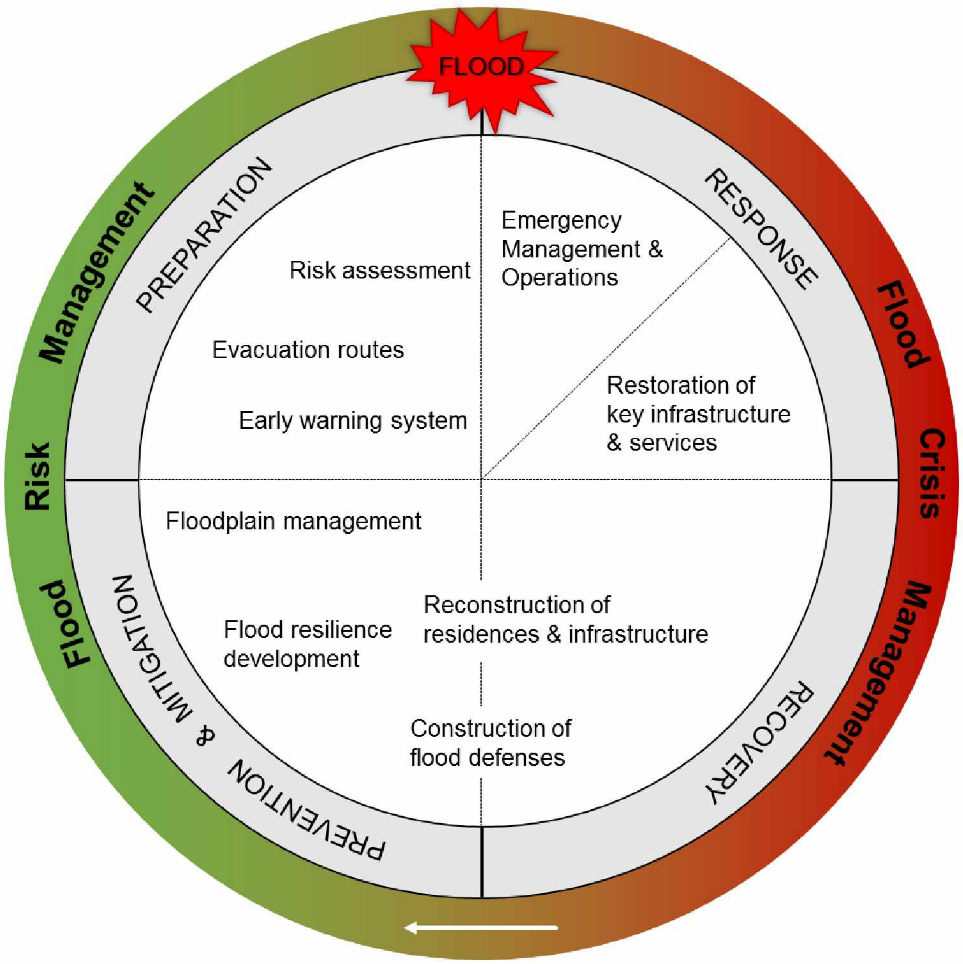

Figure 2. 7 Disaster (Flood) Management Cycle Model. Disaster risk management activities take place before a disaster strikes. In practice, disaster risk management phases are not discrete units, but mutually inclusive; and many activities overlap from one phase to another. Modified from Kontar et al., in press.

Underlying risk drivers differ in every community, and so should disaster risk management approaches. Disaster risk management falls into the three main pre-disaster phases: mitigation, prevention, and preparedness (Figure 2.7) (e.g., Neal, 1997; Twigg, 2004; Ismail-

Zadeh & Takeuchi, 2007; IPCC, 2012; Wisner et al., 2012). Disaster risk management approaches are based on the assumption that the hazard will reoccur, and therefore are aimed at reducing or eliminating the adverse impacts of future disasters.

2.3.1 Disaster Risk Cycle Model

Disaster scholars and practitioners utilize some form of a disaster cycle model (Figure 2.7) to illustrate where different phases and approaches of disaster risk and crisis management link with one another (Alexander, 2002; McEntire, 2007; Hansford, 2011). Although the configuration of disaster phases and measures vary depending on the model's use, it always features four key disaster phases – response, recovery, mitigation, and preparedness. Disaster researchers have used the disaster cycle model to systematize and codify their research (i.e., this dissertation) (Neal, 1997; Twigg, 2004). Disaster practitioners have used the model to organize their activities according to disaster phases (McEntire, 2007).

Although a user-friendly and useful tool for both disaster research and practice, the disaster cycle model should be implemented only as a heuristic device. Neal (1997) and Twigg (2004) explained that the disaster cycle model is an over-simplification, as the disaster phases are not mutually exclusive, and they do not fit together in the exact sequence, but rather overlap or blend into one another. Different disaster phases may occur simultaneously, and thus call for a combination of measures. As illustrated in Figure 2.7, rebuilding of houses and infrastructure often belongs simultaneously in disaster recovery and mitigation phases.

Neal (1997) further explained that disaster management measures that are taken or not taken during one phase directly affect disaster events and measures in another phase. For example, failing to implement mitigation and preparedness strategies before disaster strikes would complicate response and recovery measures. Nevertheless, the disaster cycle model is a helpful tool, if implemented strictly for a diagrammatic presentation of disaster phases, as it was done for the purposes of this dissertation.

2.3.2 Role of Partnerships and Stakeholders in Disaster Risk Reduction

As mentioned above, two major frameworks dominate disaster research today. On one side, proponents of the hazard paradigm assert that disasters result from extreme and rare natural hazards, and that impacted populations fail to adjust due to their insufficient perception of risk (e.g., Kates, 1971; Burton, Kates & White, 1978, McEntire, 2007). On the other hand, proponents of the vulnerability paradigm argue that disasters primarily affect marginalized population segments who lack access to the necessary resources and means of protection to withstand potential disasters (e.g., O'Keefe et al, 1976; Hewitt, 1983; Wisner et al., 2004; Cutter et al., 2015).

Until the last decade, policymakers have been predominantly adhering to the suggestions of the hazard paradigm when making disaster management decisions (Gaillard, 2010; Gaillard & Mercer, 2012; Cutter, 2013). Relying predominantly on command-and-control and top-down frameworks, national governments administrate disaster management programs to the detriment of local actions (IFRC, 2000; Gaillard & Mercer, 2012; Sendai Framework, 2015). In this scenario, local governments do not take part in disaster management planning, but are merely tasked to relay actions from the top down (McEntire, 2007; Gaillard & Mercer, 2012). Hazard paradigm also does not encourage the use of local knowledge in disaster management.

Furthermore, disaster management is predominantly executed by army or civil protection institutions, which rely on military chain of commands and top-down regulations (Wisner et al., 2004; McEntire, 2007; Gaillard & Mercer, 2012). Since the underlying economic, political, social, and cultural causes of disasters are not viewed as civil-defense matters, they remain largely ignored. After disaster recovery is completed, the vulnerability yet remains.

The global trends for the past 40 years demonstrate a continuous increase in disasters caused by natural events (Figure 2.4), thus indicating the ineffectiveness of the prevailing disaster management policies (White, G., Kates, & Burton, 2001; Sendai Framework, 2015; MünichRe, 2016). The aforementioned trends inspired a succession of international disaster risk reduction agreements and policy documents, such as the Hyogo Framework for Action (HFA) (2005) and the Sendai Framework for Disaster Risk Reduction (Sendai Framework) (2015). Drawing predominantly from the vulnerability paradigm, these treaties have been cultivating more proactive approaches to disaster management on local and regional levels (HFA, 2005; Cutter et al., 2015; Sendai Framework, 2015; IFRC, 2016a). The international disaster community has also been calling for more robust participation of local communities in disaster governance processes. Engaging local communities (i.e., the primary risk-bearers) in disaster risk reduction planning can help to identify vulnerabilities and build local capacities (HFA, 2005; Sendai Framework, 2015; IFRC, 2016a).

Integrating diverse stakeholders in disaster risk reduction, in its turn, necessitates integrating different types of knowledge (i.e., local and scientific), as well as multi-sectoral (bottom-up and top-down) actions and initiatives (Figure 2.8) (Gaillard & Mercer, 2012; Wisner et al., 2012; Cutter et al., 2015). Although increasingly regarded by both scholars and practitioners as a crucial step in reducing disaster risk, integrating knowledge, actions and stakeholders in disaster risk reduction remains challenging in policy and practice primarily due to the lack of trust among stakeholders (Brenner, 2001; Neumann, 2009; Gaillard & Mercer, 2012). Gaillard and Mercer (2012) argued that the absence of space for dialogue is the key reason for the distrust. They introduce a road map framework, with the dialogue as the central component, to facilitate the integration of knowledge, actions and stakeholders in disaster risk reduction (Figure 2.8).

The road map features a horizontal process starting with an integrated assessment of disaster risk based on local and scientific knowledge, which is followed by the establishment of a dialogue among the diverse stakeholders on issues and potential solutions, and finishes with a range of top-down and bottom-up initiatives (Gaillard & Mercer, 2012). The integrated disaster risk reduction framework appears to be most effective when implemented on ongoing bases rather than as a one-time initiative.

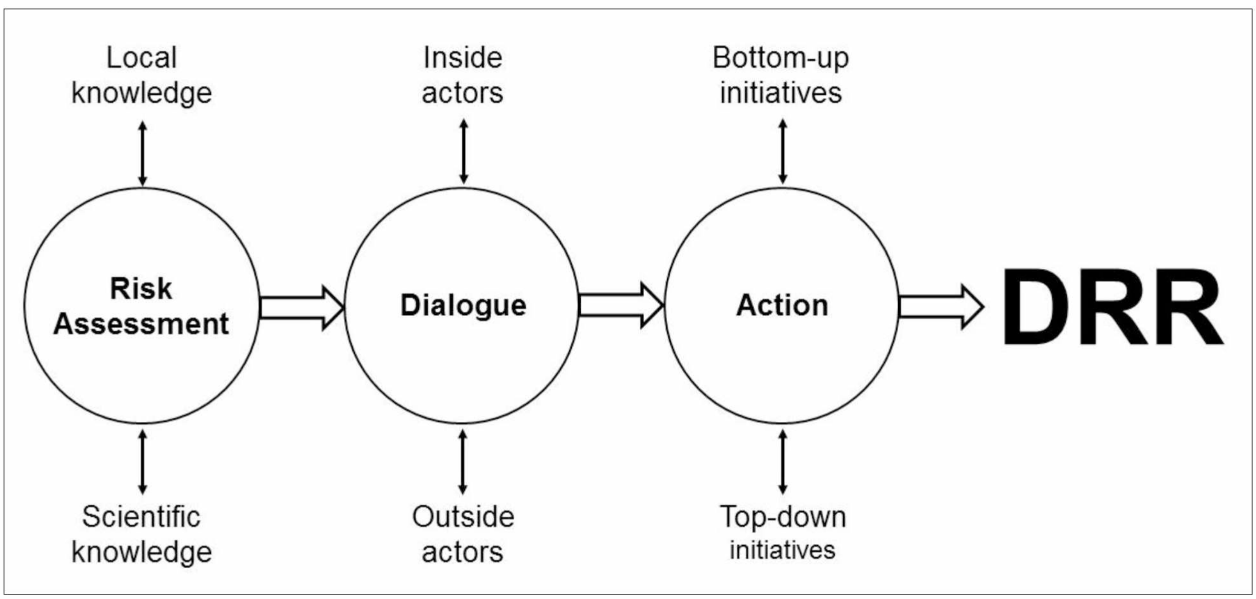

Figure 2. 8 Integrated Disaster Risk Reduction Framework. This figure outlines a road map for integrating knowledge, actions and stakeholders in disaster risk reduction. Note: inside actors comprise communities' members (including representatives from marginalized groups); outside actors comprise scientists, governments, and NGOs. Modified from Gaillard & Mercer, 2012.

Building effective stakeholder partnerships remains a key challenge in disaster risk reduction. Few multi-stakeholder projects that took place prior to this research noted significant difficulties in leveling power relationships between local people, government officials, scientists, and NGOs when encouraging integrated disaster risk reduction programs (e.g., Cronin et al., 2004a; Cronin, Petterson, Taylor, & Biliki, 2004b; Daly, Poutasi, Nelson, & Kohlhase, 2010; Fazey et al., 2010). The review of the aforementioned case studies along with the Sendai Framework (2015) and IFRC's World Disaster Report (IFRC, 2016b) revealed four key factors in establishing and maintaining effective stakeholder partnerships and encouraging interagency collaborations:

1. Understanding and trust – diverse stakeholders should understand each other's perspectives and trust each other's motivations. To achieve this, a dialogue between stakeholders about their concerns must be established and maintained.
2. Transparency – priorities of each stakeholder group should be open and inclusive of other stakeholders, and accompanied by decentralization and flexibility in the allocation of resources.
3. Incentives – clear incentives for stakeholder collaborations should be established by each stakeholder group.
4. Measurement of impact – clear and measurable indicators must be established to assess the impact of partnerships in disaster risk reduction. Incentives should be linked to the indicators.

In addition to enhanced interagency communication, disaster scholars call for decentralization to facilitate integrated disaster risk reduction. Decentralization can be viewed simultaneously as a challenge and an opportunity for effective disaster risk reduction and disaster risk management (Twigg, 2004; Scott & Tarazona, 2011; IFRC, 2016b). On the positive side, decentralization could strengthen capacities of local administration to mitigate, prepare, respond to, and recover from disasters.

As pointed out by Alexander (2002) and Gaillard and Mercer (2012), disasters are local events, which foremost impact the local population. With their overall wellbeing and survival at stake, local communities are stakeholders that are most interested in disaster risk reduction (O'Brien, Bhatt, Saunders, Gaillard, & Wisner, 2012; Sendai Framework, 2015; IFRC, 2016b). Local people are frequently also the first responders to the disaster (Alexander, 2002; Delica-Willison & Willison, 2004; Gaillard & Mercer, 2012; IFRC, 2016b). Local leaders are more likely to understand, and in most cases even share the community's needs (O'Brien et al., 2012).

Decentralization could also undermine disaster risk reduction. In many cases, local governments lack necessary financial means and/or skills to undertake substantial disaster risk management efforts, such as building embankments or relocating at-risk populations, independently from central governments (Twigg, 2004; Gaillard & Mercer, 2012; Palmer, 2013; IFRC, 2016b). Disaster risk could increase because of government decentralization.

Moreover, local governments often do not have the jurisdiction and political power to address the underlying political, economic, and social causes (i.e. root causes) of disaster risks (Gaillard & Mercer, 2012). Wisner et al. (2004) further argued that people's vulnerability largely results from structural forces (e.g. unequal access to resources, poverty, gender or ethnic marginalization, poor risk governance), which originate on national or global levels. Inferring from Gaillard and Mercer (2012) and Wisner et al. (2012), one might argue that reducing vulnerability and risks is a task of prime, but not sole, responsibility for those with power and resources (i.e., national governments). At the same time, communities at risk are not helpless and always display resilient capacities of different levels (Scott & Tarazona, 2011; Sendai Framework, 2015; IFRC, 2016b). Therefore, communities should be included in decision-making regarding disaster risk and crisis management.

2.3.3 Disaster Prevention and Mitigation

Although often used interchangeably, disaster mitigation and disaster prevention are not synonyms. Mitigation refers to lessening the adverse impacts of potential disasters through a range of structural (e.g., flood dikes) and non-structural (e.g., land use zoning) measures, while prevention refers to the complete avoidance of negative disaster impacts (Twigg, 2004; UNISDR, 2007; IPCC, 2014). In most cases, disaster prevention entails full relocation of at-risk populations and their assets from hazard-prone locations (UNISDR, 2007; Wisner et al., 2012). Often, disaster prevention is unachievable, and then transformed into mitigation efforts.

Due to its position in the disaster cycle (Figure 2.7), mitigation is most often referred to as a set of actions against potential disasters (Neal, 1997; Twigg, 2004). In reality, however, mitigation can take place before, during, or after a disaster. Today, disaster scholars and practitioners agree that recovery is the most appropriate time to implement more stringent mitigation measures (e.g., McEntire, 2007; FEMA, 2013; GFDRR, 2014; UNISDR, 2015). According to Hansford (2011) and FEMA (2013), the interest in mitigation is highest during the immediate aftermath of a disaster. The population at risk and local administration are more receptive to change when a disaster occurs. Their interest, however, declines with each week due to their need and wish to speed up recovery and resume their standard daily activities (Hansford, 2011; FEMA, 2013). Hansford (2011) further stressed that if risk reduction measures do not take place immediately after a disaster strikes the opportunities to reduce future risks would significantly decrease. This scenario would lead to the reinforcement of existing vulnerabilities, and therefore prevent a community from coping with future hazards (Sendai Framework, 2015; IFRC, 2016b).

Despite the prospective benefits of disaster mitigation, dedicated funding for preventative measures is very limited (Ismail-Zadeh & Takeuchi, 2007; Palmer, 2013; Cutter et al., 2015). There are two main reasons for this: the paucity of commitment to this issue among governments and humanitarian agencies, and the persistence of artificial divisions between emergency and development budgets (disaster mitigation and preparedness fall into the gap between the two) (Twigg, 2004; Gaillard & Mercer, 2012).

As noted by Twigg (2004), disaster mitigation tends to fall into the gap between disaster relief and development, as longer-term mitigation measures (e.g., partial community relocation and construction of dikes) tend to have much in common with development processes. Disaster scholars argue that the distinction between relief and development is artificial because risk is not a distinct sector (e.g., Wisner et al., 2012; Cutter et al., 2015). All stakeholders should be concerned with and involved in disaster risk reduction and disaster risk management. Twigg (2004) further argues that greater coherence between developmental and disaster assistance groups is essential in effective disaster risk reduction.

2.3.4 Disaster Preparedness

Despite mitigation measures, in most cases, some people and property remain vulnerable to disasters (Twigg, 2004; United Nations International Strategy for Disaster Reduction and United Nations Office for Coordination of Humanitarian Affairs [UNISDR & UNOCHA], 2008). Thus, preparedness is a key component of disaster risk management that further helps people to alleviate the negative impacts of disasters. Preparedness measures comprise activities that increase people's ability to predict, prepare for, as well as respond to and recover from disasters (UNISDR, 2007; Hansford, 2011). Effectiveness of disaster preparedness depends on the capacities and knowledge developed by multiple stakeholders (e.g., governments, professional response organizations, communities and individuals) to anticipate and respond effectively to the impact of potential and imminent hazard events (UNISDR & UNOCHA, 2008; Wisner et al., 2012).

To be effective, disaster preparedness must be based on a sound analysis of disaster risks and detailed contingency plans, and be well linked to early warning systems (EWS) (IFRC, 2000; UNISDR & UNOCHA, 2008; Wisner et al., 2012). Other components of disaster preparedness include access to resources (e.g., food, medical services, disaster relief equipment and funding), well-established communication and information channels, and disaster relief training (Twigg, 2004; McEntire, 2007; UNISDR & UNOCHA, 2008).

Twigg (2004) points out three main elements of disaster preparedness: 1) forecasting disaster events and issuing warnings, 2) initiating precautionary measures in response to warnings, and 3) facilitating timely and effective rescue, relief and assistance. Disaster preparedness, therefore, has two key aims: to help people avoid disaster threats; and to ensure that those who are impacted by a disaster receive adequate assistance (Twigg, 2004; IFRC, 2000; UNISDR & UNOCHA, 2008).

There have been great advances in hazard forecasting in recent years (e.g., the United States Geological Survey [USGS], 2005; Alcik, Ozel, Apaydin, & Erdik, 2009; Leonard, Gregg, & Johnston, 2013; Kong, Allen, Schreier, & Kwon, 2016; Girons Lopez, Di Baldassarre, & Seibert, 2017; Haro-Monteagudo, Solera, & Andreu, 2017). To sum up the interpretations in the literature, the early warning process has three inter-related stages: forecasting, warning, and response (Twigg, 2004). Disaster risk forecasting (prediction) represents the scientific and technical dimension of early warning as it is based on scientific expertise and advanced technologies (e.g., mathematical modeling, remote sensing, and surface instrument networks)

(USGS, 2005). Significant advances have been made in the timeliness and accuracy of disaster forecasts in the last decade (Sendai Framework, 2015).

Stakeholders responsible for flood preparedness and awareness disseminate disaster forecasts and warnings as recommendations for action (IFRC, 2000; Twigg, 2004). Advances in communication technology have been improving the timeliness and effectiveness of disaster warnings (Sendai Framework, 2015). Disaster warnings acquire a social dimension once they are turned into actions (e.g., evacuation) (Twigg, 2004; IFRC, 2000; UNISDR & UNOCHA, 2008). Stakeholder engagement increases and diversifies as early warning adopts institutional and political aspects (Twigg, 2004; UNISDR & UNOCHA, 2008; Gaillard & Mercer, 2012).

The literature review revealed that considerably more investments and advances have been made in disaster forecasting rather than warning (Smith, K., 1996; Twigg, 2004; McEntire, 2007; IFRC, 2000; UNISDR & UNOCHA, 2008; Sendai Framework, 2015). Twigg (2004) argued that sole forecasts, even if accurate, play a marginal role in early warning and overall disaster preparedness, if they cannot be communicated to communities at risk and decision-makers in a timely and effective manner. Interagency communication is central to all phases of disaster risk management.

2.4 Role of Communication in Disaster Risk Reduction

As mentioned above, to bridge gaps between local and scientific knowledge, and bottom-up and top-down actions, communication and coordination mechanisms must be strengthened between communities and relevant stakeholders (Global Network of Civil Society Organizations for Disaster Reduction [GNDR], 2011; Gaillard & Mercer, 2012; Sendai Framework, 2015; IFRC, 2016b). Disaster scholars and practitioners agree that communication is vital before, during, and after a hazard event, and therefore transcends and links the four main phases of the disaster risk cycle (Figure 2.7) (Lindell & Perry, 2004; Renn, 2005; McEntire, 2007; Wisner et al., 2012).

While conducting this review, I considered all phases of the disaster cycle, but predominantly focused on communication to prevent and reduce negative impacts from natural hazards, to prepare exposed and vulnerable people for potential disasters, and to enable them to better cope with the consequences. From a disaster risk management perspective, such communication takes place in the prevention, mitigation, and preparation phases (McComas, 2006; Höppner, Bründl, & Buchecker, 2010).

Applied to risk, communication can be either a one-way transfer of hazard and risk related information and their management, or a two-way exchange of related knowledge, attitudes, and values (e.g., Covello, 1992; Palenchar, 2005; McComas, 2006; Höppner et al., 2010; Coombs, 2012). Specific purposes and functions of risk communication vary depending on the local contexts. Table 2.4 provides examples of communication purposes and tasks during disaster risk management phases (Lindell & Perry, 2004, Höppner et al., 2010; Sheppard, Janoske, & Liu, 2012).

Table 2. 4 Examples of Risk Communication Purposes and Tasks.

Prevention and Mitigation (before event)	Preparedness	Mitigation (after event)
Risk assessment	Disaster/emergency warning	Damage assessment
Awareness raising	Triggering behavioral response → Encouraging protective behavior (among people at risk) → Mobilizing emergency resources (among disaster managers)	Enabling dialogue → Involve stakeholders in decision making → Encourage community members to participate in disaster mitigation → (re-) assigning responsibilities Building trust
Information provision → Where to access information on specific actions → How to interpret information	Information provision → What to do → Whom to contact	Information provision & coordination of tasks
Reassurance → Reducing anxiety → Outrage management	Reassurance → Reducing anxiety → Outrage management	Reassurance → Reducing anxiety Outrage management
Keeping memory alive → Learning from past event	Stimulating compliance with those in authority	Keeping memory alive → Learning from past event
Enabling dialogue → Develop disaster mitigation & management strategies → Assigning responsibility		

2.4.1 Evolution of Risk Communication

Despite decades of research and significant scientific breakthroughs, scholars and practitioners continue to look for ways to improve communication between diverse stakeholders about present, emerging, and evolving risks (e.g., Rogers & Kincaid, 1981; Renn, Burns, Kasperson, J. X., Kasperson, R. E., & Slovic, 1992; Fischhoff, 1995; Morgan, M. G., Fischhoff, Bostorm, & Atman, 2002; Covello & Sandman, 2001; Coombs, 2004; Drumheller & Benoit, 2004; Lindell & Perry, 2004; Kauffman, 2005; Palenchar & Heath, 2007; LaPorte, 2007; Lundgren & McMakin, 2009; Höppner et al., 2010, Sheppard et al., 2012; Drake, Kontar, &

Rife, 2014; Drake, Kontar, Eichelberger, Rupp, & Taylor, 2016; not exhaustive, only illustrative).

Historically, risk communication research mainly involved case studies, and focused on organizational risks in the midst of a crisis (e.g., reputation preservation and recovery, response, and ability to recover from crisis), rather than on communication's impacts on the public and their behaviors (Twigg, 2004; Heath & O'Hair, 2010; Sheppard et al., 2012). Common case studies include the tampering of Johnson & Johnson's Tylenol, the Exxon Valdez oil spill, the September 11, 2001 terrorist attacks, and Hurricane Katrina (e.g., Berg & Robb, 1992; Tyler, 1992; Benoit, W. L., 1995; Carey, 2003; Torabi & Seo, 2004; Vlad, Sallot, & Reber, 2006; Liu, 2007; Procopio & Procopio, 2007).

According to Frewer (2004) and Irwin (2006), the focus of risk communication began to change from simply providing the public with information relevant to hazards and risks to establishing a two-way communication between stakeholders in the 1970s. By the 1990s, communication scholars began to largely agree that effective communication must be an ongoing dialogue that takes into account societal, cultural, psychological, and cognitive factors that influence the perception of risk among diverse publics (e.g., Fischhoff, 1995; Campbell, 1996; Adam & Van Loon, 2000; Renn, 2005).

2.4.2 Conceptual Approaches to Risk Communication

The expanding research and practice in communication and disaster management has resulted in an array of approaches to risk communication. Stemming from different disciplinary background, these approaches highlight different purposes and aspects of and implications for risk communication during the disaster cycle. Lundgren and McMakin (2009) outlined the eight most common communication approaches in disasters (Table 2.5).

Table 2. 5 Conceptual Approaches to Risk Communication.

Communication Approaches	Objectives and Goals
Communication process	→ To study the single components of risk communication (sender, message, receiver) and their mutual relationships. → Influenced by classical communication studies (e.g., Shannon, 1948).
Mental model	→ To analyze characteristics, needs, and beliefs of the audience, and its perception of risks and their potential impacts. → To better understand which information the audience needs to make informed decisions, and tailor communication accordingly. → Takes roots in cognitive psychology (e.g. Slovic, Fischhoff, & Lichtenstein, 1979; Morgan, M. G. et al., 2002).
Culture and ethnicity	→ To understand cultural norms, education level, language proficiency, household structures and roles of the ethnic subcultures in affected communities. These characteristics help to understand how vulnerable people interpret risks and receive information.
Crisis Communication	→ To trigger appropriate behavior in emergencies (e.g., evacuation). → Underlying approach: risk managing agencies know what is best for population at risk, and thus only provide the information they need to quickly master the situation.
Social network contagion	→ To develop partnerships with communities' social leaders who will convey the message to the rest of the at-risk population. → Underlying assumption: people rely more on advice, opinions and behavior from individuals that surround them in their daily lives (social networks of communities).
Convergence communication	→ To involve all key stakeholders in a lasting dialogue rather than engage them in one-time and one-way communication. → Underlying assumptions: effective risk communication facilitates the exchange of cultural backgrounds and experiences between stakeholders, thus helping to anticipate and mediate conflicts (Rogers & Kincaid, 1981).
Social construction	→ To create a mutual understanding of alternative forms of knowledge (i.e., scientific and traditional) and risk perception and assessment (i.e., experimental, scientific, and social) in a two-way communication. → Underlying assumption: all stakeholders contribute objective perspectives towards risk assessment, evaluation, and management.
Social amplification of risk	→ To keep messages about risks coherent by communicating the related information through reliable sources early, often, and fully. → Underlying assumption: risks are communicated by different sources and transmitted by a number of entities that accidentally or deliberately magnify or attenuate the risks and potential impacts of hazard events. Without encouragement to do otherwise, different stakeholders disseminate and potentially amplify information that supports their views while attenuate or omit others (Kasperson et al. 1988; Renn, 2003). → Helps to understand how discourses on risk evolve and take place.

As pointed out by Höppner et al. (2010), the aforementioned approaches stem from fundamentally different assumptions regarding the nature of risk, human rationality, and the purposes of risk communication. Despite their differences, combining these approaches can increase the effectiveness of risk communication by designing the most applicable communication strategies to the prevailing risks.

To be effective, risk communication methods, foremost, must match the type of risk (Slovic et al., 1979; Fischhoff, 1995; Covello & Sandman, 2001). In addition to the physical and natural properties of a disaster, it is also important to evaluate a population's perception of risk. According to the psychometric paradigm, developed by Slovic et al. (1979), there are two key characteristics of a disastrous event that influence risk perceptions and behaviors: the degree of dread associated with a risk, and the public's familiarity with the risk. The psychometric paradigm seeks to identify, characterize, and quantify risk, thus helping disaster managers to understand how a population at risk might perceive and respond to risks (Slovic, 1987).

In most cases, natural disasters fall into the higher familiarity/lower dread group of risk characteristics. As a rule, the public develops a general understanding of the risks of natural hazards that are prone to their region via personal experience or extensive media. Impacts of the higher familiarity/lower dread risks are more observable, easier to understand, and short term (Slovic, 1987). Advances in EWS provide accurate and timely warnings, thus making it easier for the public to respond. Involuntary and having the potential to cause fatalities are the dread attributes of natural disasters.

In his review article, *Perception of Risk* published in Science in 1987, Slovic further argued that "the concept of 'risk' means different things to different people." He elaborated that 'laypeople' and disaster management experts view risk differently. According to Slovic, experts judge risk strictly in terms of quantitative assessments of mortality and destruction; while most people's perception of risk is more complex as it involves an array of psychological and cognitive processes.

The previously mentioned psychometric paradigm lies at the center of Slovic's analysis of risk perception. The paradigm was formulated by Slovic et al. (1979) largely in response to the early work of a nuclear expert Chauncey Starr. The paradigm implements psychological scaling and a multivariate analysis to qualify and predict the perceived risks among different groups of people, and their responses to those risks (Slovic, 1987). Via the psychometric paradigm, Slovic also summarized the main qualitative characteristics that influence people's judgments of the riskiness of physical, environmental and material threats. According to Slovic, people tend to be intolerant of risks that they perceive as uncontrollable, unknown or unfamiliar, having a high potential for fatalities, delayed in their manifestation of harm, or bearing an inequitable distribution of risks and benefits. The higher hazards score on the characteristics above, the higher their perceived risks, and the more people want to see these risks reduced. Slovic's analysis explained why most people have extreme fear of nuclear energy and weapons, while not fearing driving cars, despite the statistics that significantly more people have died in car accidents. Due to its familiarity, a higher risk of driving a car induces significantly less fear than a lower risk phenomenon of nuclear power.

Through the comparison between nuclear accidents and car crashes, Slovic et al. (1979) also stressed the importance of media coverage in risk perception. Even small nuclear accidents result in nation-wide unfavorable media coverage, which due to a lack of information, includes speculation regarding potential future crises. Car accidents, on the other hand, receive a relatively low media coverage, which never depicts their destructive potential. Finally, Slovic et al. (1979) pointed out that perception of risk is frequently socially and culturally informed.

Throughout the article, Slovic (1987) called for disaster experts to incorporate in their risk assessments the role of emotions and cognition in the public's conception of danger. He argued that simply disseminating more information would not decrease people's irrational fears or underestimation of dangers. To improve risk management, Slovic (1987) encouraged improved communication between disaster managers and 'laypeople.' Slovic (1987) finished the article with a recommendation to structure risk communication and risk management as a two-way process.

Two-way communication can significantly improve disaster risk management by facilitating cooperation and mutual learning, and collective decision-making among disparate stakeholder groups, each of which has a key role in disaster management (Renn, 2005; Irwin, 2006). However, financial and time constraints of disaster management practice often make one-way communication the only feasible option (Lundgren & McMakin, 2009). The dialogue approach to risk communication is challenging as it involves 'cross-cultural' communication between outside actors (disaster managers) and inside actors (community members). Inferring from Renn (2005; 2008), whether one-way or two-way communication is more appropriate always depends on the specific physical and human characteristics of a risk.

A clear communication plan should be a central component of all disaster risk reduction programs. The main idea behind disaster risk reduction is the creation of a 'culture of safety and preparedness,' in which risk awareness and the adoption of risk reducing measures are part of everyday life. Disaster risk reduction is a long-term process, thus communication should be as well. In practice, however, communication is added onto projects rather than incorporated into them as an integral part, and executed by people without specialist training or skills. As a result, communication becomes fragmented into separate, one-off, short-term interventions whose impact is rarely assessed. Consequently, such communication strategies, and thus disaster risk reduction programs have little impact.

3. Methods

This research is based on a comparative case study analysis between the two flood-prone communities of Galena in Alaska, United States and Edeytsy in the Sakha Republic, Russia (Figure 1.1). Comparative case studies, also known as collective or multiple-case studies, entail the analysis of the similarities and/or differences across two or more cases that share a common focus (i.e. two communities under flood risk) (Baxter & Jack, 2008; Bhattacherjee, 2012). Specific points of comparison between the research sites are outlined in Table 1.1.

Case study research, also known as case research, is a method of in-depth studying of a phenomenon or a process over time within a bounded system or setting (i.e., a community) (Bhattacherjee, 2012; Yin, 2012). Although Stake (2005) argues that case research is not a methodology, but rather a selection of the subject to be studied (i.e. a system bounded in time and place), other qualitative scholars view it as a comprehensive research strategy (e.g., Denzin & Lincoln, 2005; Baxter & Jack, 2008; Bhattacherjee, 2012; Yin, 2012; Creswell, 2013). Case research has a long tradition in disaster research as it facilitates the discovery of cultural, political, and social factors relevant to the phenomenon of interest (Bhattacherjee, 2012; Phillips, 2014). In this way, case research aids disaster scholars in identifying driving forces of disaster risk in a specific community.

Moreover, case research allows scientists to employ multiple methods of data collection (e.g., direct and participant observations, archival records, interviews), thus facilitating evidence triangulation and enhancing data credibility (Baxter & Jack, 2008; Bhattacherjee, 2012; Yin, 2012). Furthermore, case research allows studying the phenomenon of interest from the perspectives of multiple participants, and incorporating traditional vulnerable populations into studies (Bhattacherjee, 2012; Phillips, 2014). These particular features made case study methodology a useful fit for this research.

To identify and assess the three defining components of the flood risk in both communities – hazard, exposure, and vulnerability – a bilateral and multidisciplinary team of experts was assembled. The team was established as part of the US Department of State, US-Russia Peer-to-Peer Dialog Initiative. The project lasted from October 2015 through September 2016. The team consisted of US and Russian geoscientists, social scientists, graduate students, emergency managers, and civil and tribal community leaders. Each of the team participants represented a group among stakeholders that takes part in disaster risk reduction in both countries, and shared his/her expertise with the relevant counterparts. Throughout the project, I systematically collected, analyzed, synthesized the data, and outlined emerging concepts and patterns in disaster risk reduction in Alaska and the Sakha Republic.

The data was acquired through a combination of two key sources of evidence in case research (Bhattacherjee, 2012; Kontar & Trainor, 2016):

→ *direct observations* of flood sites in both communities and interactions between local administration and residents during site visits; and

→ *reviews of documents and archives (secondary data review)* that included governmental and institutional reports, news articles, and feature stories that depicted natural and human factors during the recent and historical catastrophic floods in Galena and Edeytsy.

To facilitate data triangulation, the data acquired via direct observations and archival review was supplemented with data obtained through the additional two qualitative research methods:

→ *focus groups* with the representatives from regional and national agencies responsible for flood risk reduction and emergency management in Alaska and the Sakha Republic; and

→ *surveys* administered to the populations that were impacted by the recent floods in both research sites.

3.1 Case Study Selection

The main reason Galena and Edeytsy were selected as research sites is because both communities experienced their last disastrous flood within a week of each other in May 2013. With several residences remaining under reconstruction, the memories of the floods are still alive in both communities. Furthermore, both communities are prone to major spring floods. Historical flood records revealed driving forces of the flood risk in Galena and Edeytsy, and the transformation of flood risk reduction efforts in both regions.

Besides physical risk, another reason for the selection was the enthusiasm shown by the communities' leaders in many areas of flood risk reduction on the local level. Tribal and municipal leaders in Galena, and municipal leaders in Edeytsy have been actively pursuing flood mitigation opportunities (e.g., construction and reinforcement of dikes, partial relocation of population from the flood-zone, and raising buildings on pilings), and enhancing community flood awareness and preparedness plans.

The final reason for the research site selection is the interagency involvement in flood risk and crisis reduction efforts in Galena and Edeytsy. The 2013 floods caused multi-million dollar damages in both communities, impelling local administrations to call for state and federal disaster response and recovery funds. As a result, an array of stakeholders from governmental, non-governmental, public and private sectors were engaged in flood relief and recovery in both regions (Table 1.2, Table 1.3). For that reason, Galena and Edeytsy provided a great opportunity to compare and contrast collaboration and communication between the diverse stakeholders involved in disaster risk reduction in both regions.

3.2 Data Collection

As mentioned above, a comprehensive qualitative case study presents an in-depth understanding of the case. To provide the necessary "depth" to the case, a researcher should use many different information sources (Bhattacherjee, 2012; Creswell, 2013). To conduct this research and provide a thorough understanding of the flood risk reduction in Alaska and the Sakha Republic, I used four sources of information: focus groups, field surveys, direct observations, and secondary data.

To collect the necessary data, I participated in one site visit to Edeytsy in November 2015, and three site visits to Galena in March 2015, March 2016, and May 2016. During the site visits I recorded (i.e. kept field notes and took photographs) my observations of human actions and the physical environment, conducted focus group research, informal interviews, and administered surveys. I conducted secondary data analysis prior to the site visits with the goal to accurately structure survey questions (Table 3.1), and after the site visits to check the consistency of the findings. Through the extensive data collection, I assembled a thorough description of both cases, in which I detailed the vulnerability progression in Edeytsy and Galena, and made a chronology of the key events and activities of the primary stakeholders before, during, and after the floods in May 2013.

Prior to engaging in research, I gained the necessary permissions from the institutional review board (IRB) as well as individuals at the research sites (Appendix A). With the goal to establish rapport with the community leaders, I reached out to the Mayor of Galena in March

2015, approximately a year prior to the field research. After learning about the project, he invited me to Galena to volunteer at the Iditarod Trail Sled Dog Race (an annual long-distance sled dog race). Since Galena is a checkpoint for the dog mushers, the Iditarod attracts many locals as volunteers or spectators. It was a great opportunity to meet with Galena residents, spread the word about the project, and observe community dynamics. Galena's Mayor and First Tribal Chief participated in every major step of the research, from proposal writing to protocol compositions for surveys and focus groups. The project's participants from the North-Eastern Federal University (NEFU) in Yakutsk, Sakha Republic established rapport with Edeytsy's administration. Although residents in Galena and Edeytsy were well informed about the project, they were provided with a copy of the Consent Form, which was attached as the first page to the paper surveys or written as an introduction to the online surveys (Appendix B).

3.2.1 Focus Groups

As part of the Peer-to-Peer project, the research team organized and facilitated three focus groups in the Sakha Republic in November 2015, and two focus groups in Alaska in March 2016. Focus group research involves assembling a small group of subjects (preferably 6-10 people) for a moderated discussion about a phenomenon of interest for 1.5-2 hours (Bhattacherjee, 2012). Focus group research helps researchers to build a holistic understanding of the subject under investigation based on the participants' comments and experiences.

The main goal of the focus groups in Alaska and the Sakha Republic was to identify the existing practices in flood risk reduction, as well as the key challenges (e.g., logistical and financial) various stakeholders face during flood risk and crisis management in both regions. Therefore, the participants in the focus groups included representatives from regional and national agencies and institutions involved in flood risk reduction efforts, university and federal scientists that study natural and human causes and impacts of spring floods and other disasters in the North, and representatives from local, regional, and tribal administrations of the at-risk communities.

In the role of an assistant moderator, I took detailed notes during all focus groups. I also collected supplementary materials, such as PowerPoint presentations and media files, which were presented by the focus group participants. I ensured that the notes were clear and consistent, and included key points and themes for each question, quotes, and follow up questions. After each focus group, I compared my notes with the co-assistant moderator(s) (i.e., Peer-to-Peer co-participants) to double-check their validity.

3.2.2 Field Surveys

During the site visits to Galena and Edeytsy, we also administered surveys (i.e., paper questionnaires) among the residents who had experienced the 2013 floods. The main goal of the surveys was to assess opinions, perceptions, and attitudes in both research sites regarding the effectiveness of the flood risk and crisis management efforts. Field surveys are a tool to capture snapshots of beliefs from a random sample of subjects in field settings through a survey questionnaire and sometimes a structured interview (Bhattacherjee, 2012).

In rural northern communities, spring floods impact families as a whole. Therefore, we distributed the surveys among households. The information about the study and surveys was disseminated among the households by the local and tribal administrations in both communities via telephone and social media, as well as local radio (in Galena). We distributed the surveys during a specially organized committee meeting in Edeytsy and a potlach (a gift-giving feast practiced by Indigenous Alaskan Peoples) in Galena. During both gatherings, our research group made a series of presentations about the risk of and measures against spring floods in Alaska and the Sakha Republic. We explained the goals of our research, and asked the attendees to take part in our research by completing the surveys. In Edeytsy, participants filled out surveys during or immediately after the meeting, while in Galena most respondents asked to complete their questionnaires later. To simplify the survey distribution-and-collection process, Galena residents filled out electronic questionnaires via SurveyMonkey (https://www.surveymonkey.com/home/), a free online survey software. Print copies were available for participants who preferred to fill out paper surveys. To facilitate the analysis, the data from the paper surveys was transferred to SurveyMonkey program.

Our samples include 32 families (~17%) out of the 190 in Galena, and 60 families (~22%) out of the total 276 in Edeytsy. All survey participants volunteered to take part in the research because they were interested in the subject and had an opinion to express. Selection criteria for survey participants included residency in Galena and Edeytsy during the 2013 floods, and membership in a household. All of the survey participants were literate and over the age of 18. The surveys administered at each research site were identical with the exception of a few adaptations to localized cultural and logistical features of the communities. The surveys included closed and open-ended questions, and collected numerical and narrative data. The surveys comprised 38 questions split into nine groups (Table 3.1). I predominantly analyzed the first five question groups to answer the research questions of this dissertation.

Table 3. 1 Survey Design and Content. Highlighted fields indicate the question groups analyzed in this dissertation.

GRP 1	Qs 1-4	History of floods in Galena and Edeytsy
GRP 2	Qs 5-13	Socioeconomic impacts of the 2013 floods
GRP 3	Qs 14-18	Local ice jam and flood mitigation and preparation efforts
GRP 4	Qs 19-20	Flood information and warning channels
GRP 5	Qs 21-25	Assistance efforts from governmental and non-governmental agencies involved in flood response and recovery
GRP 6	Qs 26-28	Correlation between floods and population relocation
GRP 7	Qs 29-31	Quality of drinking water during and after floods
GRP 8	Qs 32-34	Sanitary-epidemiological and health impacts of floods.
GRP 9	Qs 35-38	Socioeconomic demographic characteristics of the respondents

3.2.3 Direct Observations

During site visits, I also collected data through direct observation. Observational study is a method of collecting information by noting the subjects in their usual environment (without altering it) through the five senses (Creswell, 2013). Direct observation is one of the most common qualitative research methods, and one of the distinctive features of conducting case study research (Yin, 2012). During observations, I wrote notes and made photographs that depicted flood destruction, recovery efforts, and community dynamics. I also kept notes of my conversations with community members and emergency managers. My observational protocol consisted of both descriptive and reflective notes, and was organized by the data, place, and time of observation. Depending on the setting, I participated in the activities on site either as a participant observer (i.e., engaged in activities and conversations with the project population), or a complete observer (i.e., strictly observed the project population); a few times, I changed my role during an observation.

3.2.4 Secondary Data

Secondary data includes data that has previously been collected and tabulated by other sources for a different purpose (Bhattacherjee, 2012). I gathered a range of archival data dating back to the early twentieth century: historical hydrological and climatological reports as well as news stories, feature stories, and governmental reports that described ice jam floods and their causes and impacts in Alaska and the Sakha Republic. I also collected memoires and other personal reflections of Galena residents on the historical floods. Overall, archival records proved a wealth of information on the transformation of the flood risk reduction in both regions, as well as progression of vulnerability in both communities.

3.3 Data Analysis

According to Cowells (2013), qualitative data analysis involves four main steps: 1) organizing collected data, 2) reducing the data to codes and organizing codes into themes, 3) forming an interpretation, and 4) representing the interpreted data through discussion, figures, and tables. Analyzing a case study also requires a thorough description of the case in its setting. In my data analysis, I spent considerable time describing the two cases. The descriptions include a chronology of events leading to the disastrous impacts of the 2013 floods in Galena and Edeytsy. Next, I systematized the data into appropriate categories, and compiled the categories into general themes. I ended my analysis by comparing and contrasting the themes of the two cases.

3.3.1 Focus Group Data Analysis

I reviewed and compared my notes with the other project participants immediately after each focus group. Next, I organized and coded my notes in the QSR NVivo (a qualitative data analysis computer software package that enables use of English and Russian languages). I also reviewed and outlined the key themes featured in the PowerPoint presentations shared during the focus groups.

3.3.2 Survey Data Analysis

I used SurveyMonkey to analyze survey results from both research sites. As mentioned above, most Galena residents completed their questionnaires via the online software. I manually transferred the remaining written questionnaires from Galena and Edeytsy to the software. I concluded the analysis of survey results by constructing comparative charts via Microsoft Excel and Venngage (www.venngage.com), a chart and infographic-building program.

3.3.3 Direct Observations Data Analysis

I conducted initial analysis of my observations immediately by assembling my reflections into thorough narratives about the people and events under observation. I later organized and coded my observations to outline the repeating themes. I also triangulated the repeating themes with the information obtained from the secondary data review, focus groups, and surveys. I concluded the analysis by comparing and contrasting the repeating themes in both research sites.

3.3.4 Secondary Data Analysis

Using QSR NVivo, I organized, analyzed, and coded important documents thematically. I identified key themes and subthemes in flood risk reduction practices in Alaska and the Sakha Republic. Next, I cross verified the themes and subthemes with the flood management strategies mentioned by the participants in the focus groups and surveys, and outlined in the academic literature and disaster practitioners' reports.

4. Understanding Springtime Flood Risk in Alaska and the Sakha Republic

River ice thawing and breakup is an annual springtime phenomenon in the North. Depending on regional weather patterns and river morphology, breakups can result in floods (Beltaos, 2003; Buzin, 2004). Breakup floods often cause catastrophic ice and water damage to exposed and vulnerable communities, and lead to socioeconomic and ecological crisis (e.g., Beltaos, 1983; Gerard & Davar, 1995; Buzin, 2004; Pagneux et al., 2011; Burrell et al., 2015; Kontar et al., 2015).

No reliable means of predicting the severity and timing of breakup floods with a significant lead-time yet exist. Thus, the populations at risk rely on flood mitigation and preparedness, and well-coordinated disaster response to save lives and property (White, K., 2003; Prowse, Bonsal, Dungway, & Lacriox, 2007; Denver, 2016). Unique regional features, such as vast distances, limited physical and communication infrastructure, and short rebuilding season, challenge and delay flood relief and recovery in the North (Kravitz & Gastaldo, 2013). As a result, impacted populations are often forced into long-term evacuation. A switch to a predominantly proactive management of spring floods through upfront investments in flood risk reduction, may significantly reduce or ideally eliminate immense reconstruction and recovery costs, and most importantly loss of life.

Accurate assessment of flood risk components is an essential part of effective flood risk reduction (Twigg, 2004; UNISDR, 2015). As with all natural disasters, spring floods result from a complex interaction between a series of natural and human processes and events that generate the three defining components of flood risk – hazard, exposure, and vulnerability (Figure 2.1.) (Wisner et al., 2012). Via a comparative analysis of two flood-prone communities, Galena in

Alaska, United States and Edeytsy in the Sakha Republic, Russia (Figure 1.1), I outlined and analyzed driving forces of spring flood risk in northern rural communities.

Within a week of each other in May 2013, Galena and Edeytsy sustained major floods; floodwaters and ice debris destroyed nearly all residences and infrastructure and displaced hundreds of people (Kontar et al., 2016). As outlined in the Introduction chapter, impacted populations in both communities not only lost their homes, but also their livelihood. Floodwaters and ice debris caused multi-million dollar damages: over $10 million dollars in Edeytsy, and over $71 million dollars in Galena (Korta, 2016; Yadreev, 2016; Gavrilyeva et al., in press; Kontar et al., in press).

Although extreme, the 2013 floods were not isolated instances in either Galena or Edeytsy. Galena faced two major spring floods in May 1971 (the largest flood to date) and May 1963, while Edeytsy's previous large flood was in May 2010 (Morgan, L., 1972; Kusatov, 2015; Pelkola & Korta, 2015; S. Struchkova, personal communication, November 10, 2015; Yadreev, 2016). The survey respondents from Galena indicated 11 incidents of minor and moderate flooding over the last 50 years (1966, 1971, 1972, 1977, 1984, 1989, 1991, 1992, 1994, 2000, and 2001). The flood years were cross-referenced with the flood records from the Alaska-Pacific River Forecast Center (RFC) and the U.S. Army Corps of Engineers (USACE) (USACE, 2003; Galena Breakup Events, 2016).

Edeytsy survey respondents indicated the following flood years from the last 50 years: 1968, 1978, 1997, 2007, 2009, 2010, 2011, 2012, and 2013. The dates were cross-referenced with the flood records from the Roshydromet (Kusatov, 2015; S. Struchkova, personal communication, November 10, 2015; Yadreev, 2016). All floods originated due to ice jams –

accumulations of stationary ice in a channel that block the river flow during springtime melting (Beltaos & Prowse, 2001; Plumb, 2015; Yadreev, 2015).

4.1 Understanding the Hazard: Ice-Jam Floods

Ice jams are an integral part of the hydrologic regime of northern rivers. They occur in all Arctic and sub-Arctic regions, often leading to rapid and significant rise in water levels and both negative and positive impacts (Beltaos, 2007; Buzin, Goroshkova, & Strizhenok, 2014). For example, ice-jam floods can cause severe damage or destruction to infrastructure and property, interference with navigation, impedance of hydropower generation, and disruption of aquatic habitant, while also replenishing a fragile ecosystem with water and nutrients (Buzin, 2004; Beltaos & Prowse, 2009; Prowse et al., 2011; Burrell et al., 2015). In this dissertation, I focus predominantly on the adverse socioeconomic impacts of ice jam floods on rural northern communities.

Ice-jam floods are hydro-meteorological hazards, because they originate as a result of hydrological and atmospheric processes (Twigg, 2004; Beltaos & Prowse, 2009; UNISDR, 2007; Wisner et al., 2012; Buzin et al., 2014). Ice-jam floods are unique hazards due to their geographic (i.e., sub-Arctic and Arctic) locations, as well as presence of ice debris, which intensifies the threat of death and severe injuries, as well as destruction and damage to houses and infrastructure. Shared characteristics with other floods include:

- *rapid onset and draining*, which are also difficult to predict with precise accuracy;
- *variable duration*, which can last from a couple of hours to several days; and
- *variable frequency,* which complicates flood reduction efforts by challenging long-term mitigation solutions, and hindering community disaster preparedness. Long-

return periods of disasters eliminate memory of potential threats (i.e., Galena's New Town), and therefore discourage yearly flood preparedness.

Ice jams can form anywhere in a river channel where its transport capacity is restricted by natural or man-made obstructions (Beltaos, 2007). Common obstructions can be of natural origins and include river bends (as in Galena), mouths of tributaries, and braided streams (as in Edeytsy) (Androsov, 2015; Plumb, 2015). Examples of man-made obstructions include bridges and dams (Beltaos et al., 2006). Ice jams can hold for days and in the process force melt water and ice debris to back up for miles and cause flooding upstream (i.e., Galena and Edeytsy). When suddenly released, ice jams can cause flash floods downstream as well (Beltaos, 2007).

Locations of ice jam formations near flood-prone communities or strategically important infrastructure are well known and monitored by scientists, emergency managers, and concerned residents (White, K., 2003; Androsov, 2015; Kostin, 2015; Denver, 2016; Yadreev, 2016). For example, breakup floods in Galena and Edeytsy are caused by ice jams that have historically occurred at the same locations (Bishop Rock, Alaska and At-Ary, the Sakha Republic) downstream from the communities (Figure 4.1a,b) (Kostin, 2015; Plumb, 2015).

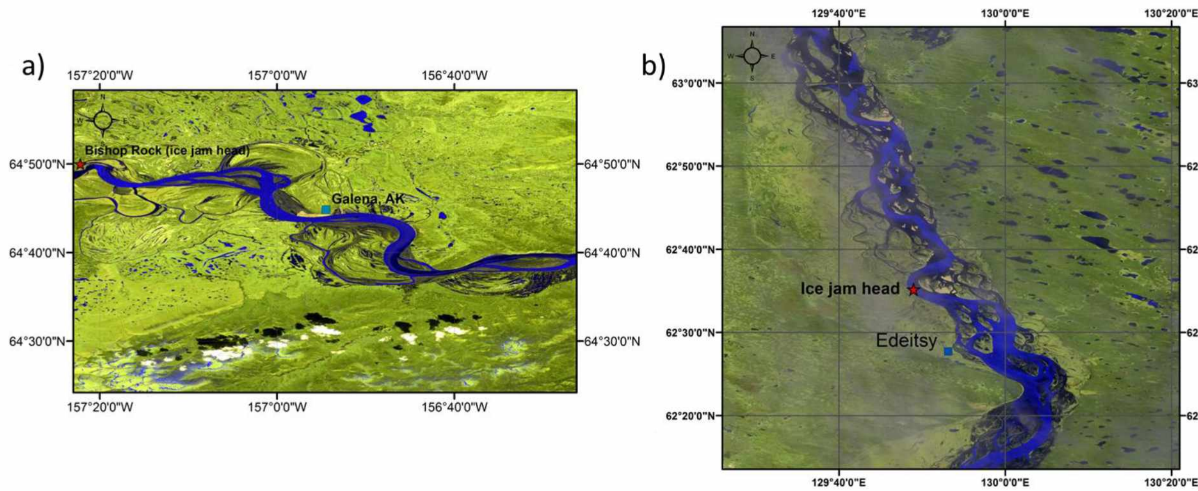

Figure 4. 1(a) Location of Ice Jam Formation, Yukon River, Alaska. Ice jam originated at Bishop Rock and backed up the floodwater and ice debris to Galena, Alaska on May 27, 2013; **(b) Location of Ice Jam Formation, Lena River, Sakha Republic.** Ice jam originated at At-Ary and backed up the floodwater and ice debris to Edeytsy, Sakha Republic on May 14, 2013. Images: Landsat-8; light blue – ice; dark blue – open water. Author's note: Edeitsy is alternative transliteration of Edeytsy. Modified from Tananaev, 2016.

University and government scientists from around the world have been experimenting with numerical and physical modeling in combination with field observations and measurements to investigate the mechanics of ice jam formation and release, and explore possible mitigation efforts (e.g., Beltaos, 1995; Jasek, 2003; Buzin, 2004; She, & Hicks, 2006; White, K., Hicks, Beltaos, & Loss, 2007; Kuchment & Singh, 2009; Carson et al., 2011; Kusatov, Ammosov, Kornilova, & Shpakova 2012; Burrell et al., 2015). However, no reliable means of predicting the timing of ice-jam floods with a significant lead-time yet exist (Mahabir, Hicks, & Robinson, 2006; Prowse et al., 2007).

In large northern rivers (i.e. Lena River and Yukon River), ice jams occur every year; but the severity of ice jam floods differs strongly from year to year (Burrell et al., 2015). Key natural factors that influence severity and duration of ice jams and subsequent floods include discharge, channel width and slope, hydraulic resistance, ice cover thickness and strength, water temperature and heat transfer, and rapid spring time temperature warming (Beltaos, 2003; Buzin et al., 2014).

Extreme changes in local air temperatures played a key role in the severity of the 2013 flood in Galena (Kontar et al., 2015). April and early May 2013 were the coldest since 1924 at all long-term observation stations in Interior Alaska. The monthly mean temperatures were significantly below freezing (Figure 4.2a). In early May, temperatures were consistently much warmer over the headwaters and upper Yukon River drainages than across central Alaska (Figure 4.2b). Significant melting in the headwaters initiated the river ice breakup. However, the ice in Interior Alaska was still strong and even grew in thickness. As a result, several ice jams formed along the middle reaches of the Yukon. The ice jam at Bishop Rock (Figure 4.1a) was so strong that it held for three days, backing the floodwaters and ice debris almost 30 km upstream to Galena, and 20 km kilometers beyond (Kontar et al., 2015).

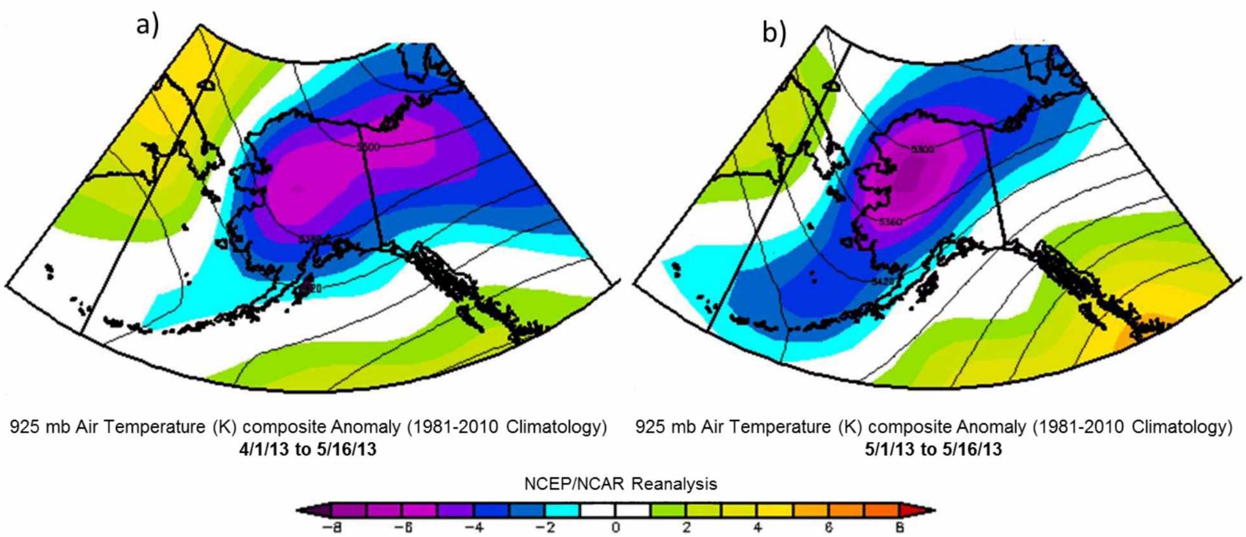

Figure 4. 2 (a) Average Temperature Departure Plot, Interior Alaska, April 1-May 16, 2013; (b) Average Temperature Departure Plot, Interior Alaska, May1-16, 2013. Image provided by the NOAA/ESRL Physical Sciences Division, Boulder Colorado from their Web site at http://www.esrl.noaa.gov/psd.

No weather extremes or anomalies were observed during and prior to the flood in Edeytsy (Figure 4.3a,b). At all long-term observation stations along the Lena River, April through early May 2013 temperatures were close to average. Furthermore, the temperatures in the central and northern parts of the Lena River watershed in early May 2013 were warm (Figure

4.3b). Thus, the breakup was uniform throughout the main channel, where no major ice jams were reported. The ice jam that caused flooding in Edeytsy formed due to the accumulation of ice chunks in the shallow braided streams (approximately 40 km downstream) and low water discharge (Androsov, 2015; Tananaev, 2016; Yadreev, 2016).

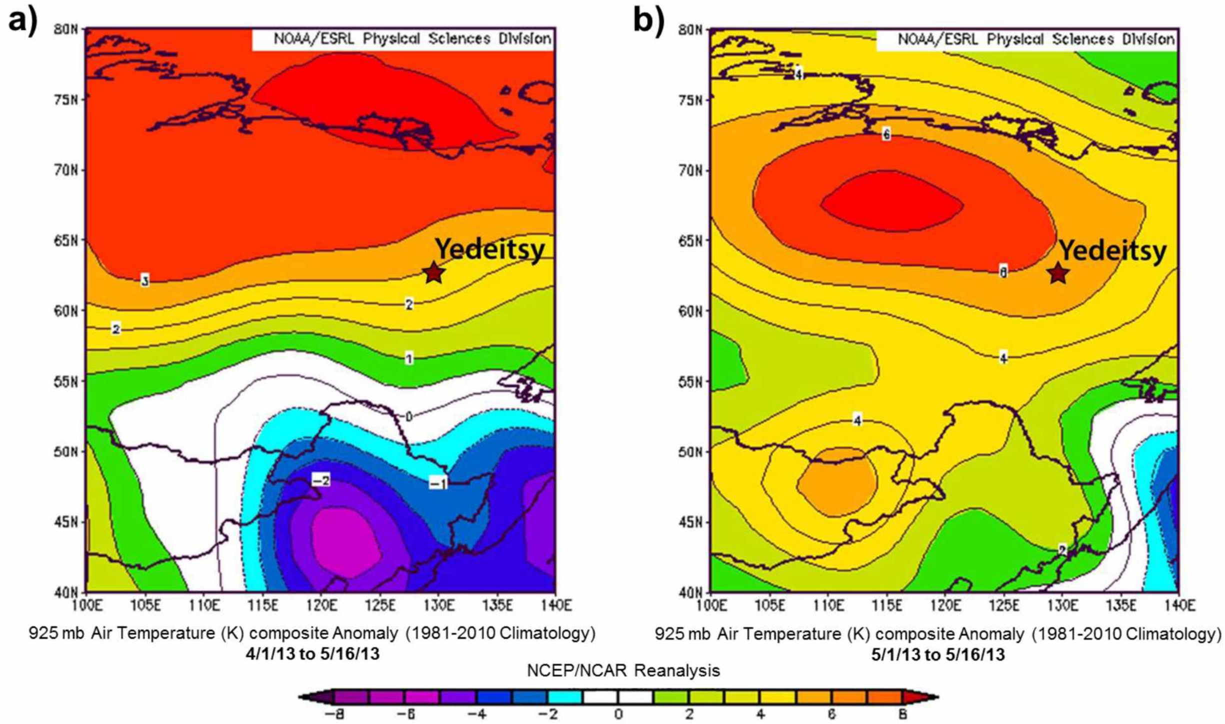

Figure 4. 3 (a) Average Temperature Departure, Central Sakha, April 1-May 16, 2013; (b) Average Temperature Departure, Central Sakha, May 1-16, 2013. Image provided by the NOAA/ESRL Physical Sciences Division, Boulder Colorado from their Web site at http://www.esrl.noaa.gov/psd. Author's note: Yedeitsy is the alternative transliteration of Edeytsy.

In general, spring floods are more frequent on the Lena River because it flows northward. According to Scrimgeour et al. (1994) and Prowse et al. (2011), the ice jam and flood risk is higher on rivers in which snowmelt, runoff and the breakup front proceed downstream with the seasonal advance of warm weather. During the breakup, the upstream ice in the southern reaches is freed first and begins to float toward much colder and stable ice covers in central and northern reaches. Thus, the spring flood wave pushes against the intact ice sheet. As a result, ice jams form easily and dam the water flow.

Ice jam floods often trigger secondary and multiple cascading hazards (e.g., contamination of water and soil, and riverbank erosion), thus further intensifying disasters (Prowse, 1995). According to survey respondents and reports from the State of Alaska Department of Environmental Conservation and Institute of Natural Sciences in Yakutsk, Sakha Republic, the ecological conditions in Galena and Edeytsy were reported as unsatisfactory for three months after the floods (Petrova, 2015; Adamczak & Sartz, 2016). Floodwaters spread pollutants and toxic waste from washed out dumpsites, outhouses, and sewage lagoons and damaged fuel tanks (in Galena).

In summary, spring river ice breakup and ice jams are natural phenomena that, under certain regional weather patterns and river morphology, cause extensive floods and consequent socioeconomic and ecological crisis. Understanding physical processes that cause ice jams and subsequent flooding in specific communities are crucial in flood risk reduction. Specifically, an accurate hazard assessment helps to develop appropriate ice jam and flood mitigation and prevention strategies, as well as enhance community preparedness and flood relief measures. However, the floods will turn from hazards to disasters only if people and/or their assets are exposed to them.

4.2 Exposure Drivers in Edeytsy and Galena

Exposure is a defining component of flood risk, which refers to the presence and number of people, plus their resources and assets in flood-prone locations (UNISDR, 2007; IPCC, 2014). If no people or their assets are exposed to an ice-jam flood during its occurrence, then there is no risk, and subsequently no disaster. Key exposure drivers include population growth, urbanization, migration, economic development, and cultural heritage (GFDRR, 2014; UNISDR, 2015). As mentioned in the Introduction chapter, political and economic incentives (e.g., establishment and maintenance of the USAF base in Galena and kolkhoz in Edeytsy) played key roles in the original settlement of Galena and Edeytsy in their current flood-prone locations, and their further growth in flood exposure.

Traditionally, Native communities in Alaska and the Sakha Republic avoided spring floods by not establishing permanent settlements in floodplains. Seasonally nomadic, Native Alaskans migrated between their fishing and hunting camps (Arundale, 1985; Sprott, 2000). Native Sakha originally settled around lakes located on higher ground, and descended to the rivers only for fishing and transportation purposes (Lindenau, 1983; Argunov, 1985; Vakhtin, 1992). Compelled by government programs to settle on floodplains in more permanent structures and communities in the first half of the 20th century, Native Alaskans and Sakha began to face flood risk (Kontar et al., 2016).

As stated previously, flood risk increases as more people and assets become exposed (UNISDR, 2009; Wisner et al., 2012). Hereby, the growing concentration of people, infrastructure, livelihoods, and services close to the riverbanks has been driving flood exposure in Galena and Edeytsy for the last eight decades (Gavrilyeva, et al., in press; Kontar et al., in press). Attempts to reduce exposure have been implemented in both communities with varying degrees of success. For example, construction of a dike had been initiated in Edeytsy after the flood in May 2010; construction continues six years later due to incremental funding (Figure 4.4) (Yadreev, 2016). In 1944, a dike was constructed in Galena to protect the airfield and the USAF infrastructure (Mongin, Mesloh, & Beck, 1972 as cited in Kontar et al., 2015). Old Town, the original native settlement, is located between the dike and the river, and thus is completely exposed to ice-jam floods (Figure 4.5) (FEMA, 1983).

Figure 4. 4 Construction of Dike in Edeytsy. (left) construction of the dike in Edeytsy after the flood in May 2010; (right) a partially constructed dike in Edeytsy, May 2011. Modified from Yadreev, 2015.

According to Denver (2016) and Korta (2016), the dike came very close to breeching during the flood in May 2013, and still needs to be repaired to sustain future floods. The airfield and former airbase infrastructure are crucial during flood relief and recovery operations. The water-free airfield facilitated evacuations and transportation of emergency personnel and supplies to the flood-ravaged community, while the impacted population took shelter in former USAF barracks, transformed into boarding school dormitories (Denver, 2016; Korta, 2016).

To further exposure reduction in Edeytsy, the state administration allocates housing certificates to the residents whose houses are prone to flood damage. Populations, whose permanent residences were destroyed during a natural or technological disaster, qualify for housing certificates – warrants for the allocation of new housing or financial means for its purchase (Organization for Economic Co-operation and Development [OECD], 2015). Recipients of housing certificates must sign off their destroyed property and the adjacent land to the state government. According to Yadreev (2016), eight Edeytsy families used housing certificates to relocate to Yakutsk, the Republic's capital, since the 2010 flood.

Figure 4. 5 Galena's Old Town, May 2013. Old Town is located between the dike and the Yukon River (Modified from Plumb, 2015).

A partial relocation of the at-risk population was also implemented in Galena after the 1971 ice-jam flood. A large segment of Galena residents relocated to higher ground further from the floodplain after a major flood in May 1971 to the subdivision New Town, a little over one mile away from the original settlement (Morgan, L., 1972; Sprott, 2000; Kontar et al., 2015). Despite regular minor and moderate flooding in the region, New Town remained dry for four decades. According to Pelkola and Korta (2015), the 40-year long absence of floods impelled New Town residents to develop a false sense of security. As a result, a large portion of Galena's population was caught off guard by the 2013 flood. No lives were lost, but lack of flood preparedness and mitigation resulted in catastrophic damages to people's homes, movable assets, and New Town infrastructure (e.g., road, school, elder home, clinic, and village and tribal council building) (Kontar et al., 2015; Taylor et al., 2016; Gavrilyeva et al., in press).

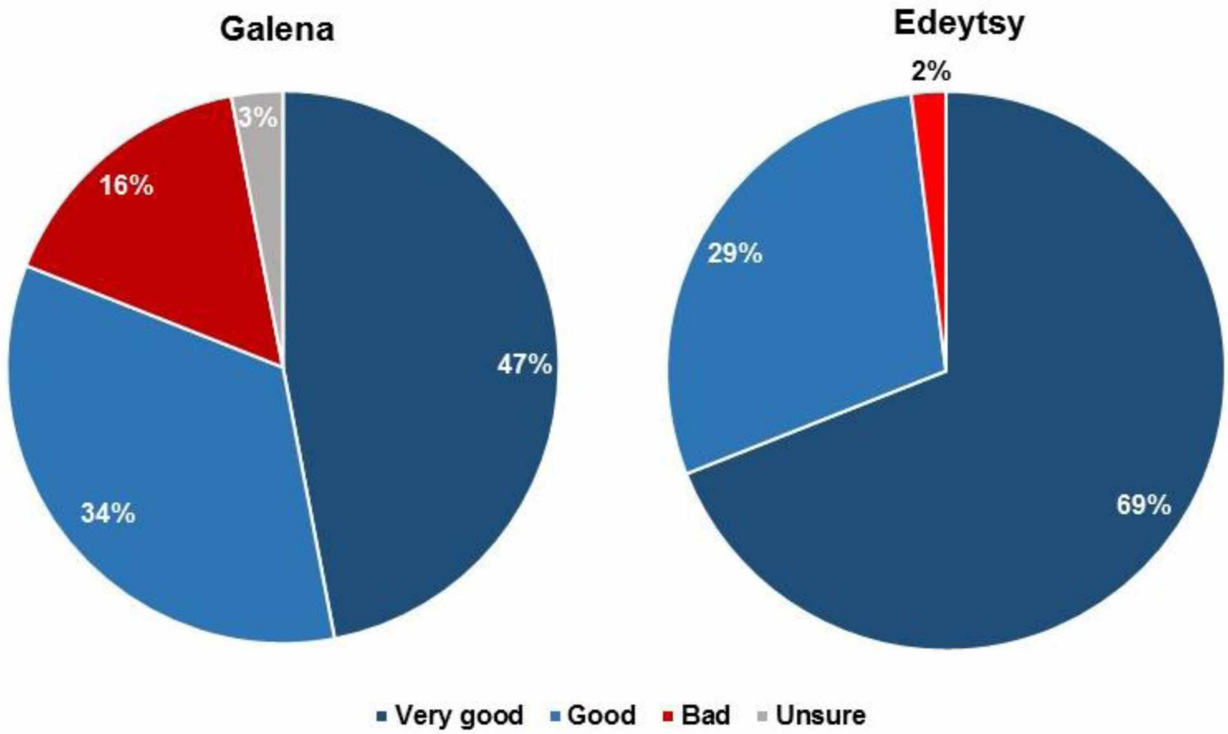

Figure 4. 6 Comparative Chart of Local Assistance. Evaluation of assistance efforts provided by the local administration in Galena and Edeytsy to their communities during the 2013 floods.

Preparedness and contingency planning that incorporate timely flood warnings and evacuation of people, their movable assets and livestock, also help to reduce exposure, and thus prevent casualties and minimize flood damages (GFDRR, 2014).

Experienced with more frequent severe flooding and having a contingency plan in place, Edeytsy residents were more proactive in relocating their cattle, farm equipment and personal vehicles to higher ground. Over 90% of Edeytsy survey responders avoided flood damages beyond their homes and outbuilding, while over half of Galena respondents reported the additional loss of vehicles and machinery. Most Galena residents lost their dog teams (Taylor et al., 2016). No loss of cattle was reported in Edeytsy (Yadreev, 2016).

Despite the lack of adequate flood preparedness planning in Galena, fatalities and major injuries were prevented due to timely flood warnings, and effective evacuation of the at-risk population. Survey respondents in both communities largely attribute the effectiveness of evacuation and immediate rescue operations to the efforts of local administrations, outstripped only by the efforts of neighbors and relatives. Over 81% of survey respondents in Galena and 95% of respondents in Edeytsy rated the efforts of the local administration (e.g., assisting with evacuation, and informing the population about potential floods) during spring flooding as good or very good (Figure 4.6). Over 83% of Galena respondents and 95% of Edeytsy respondents rated the assistance they received from their neighbors above all other sources (Figure 4.7, Figure 4.8).

The high effectiveness ratings of the neighbors validate the notion that local people (i.e., neighbors) are often the first respondents to the disaster (Alexander, 2002; Delica-Willison & Willison, 2004; Gaillard & Mercer, 2012). In the case of small settlements such as Galena and Edeytsy, community administrations are the neighbors. For that reason, local leaders are likely to understand and, in most cases, even share the community's needs during a flood. Thus, more robust participation of local communities in decision-making regarding the flood managing process is advised for effective flood risk and crisis management (Cutter et al., 2015; Sendai Framework, 2015).

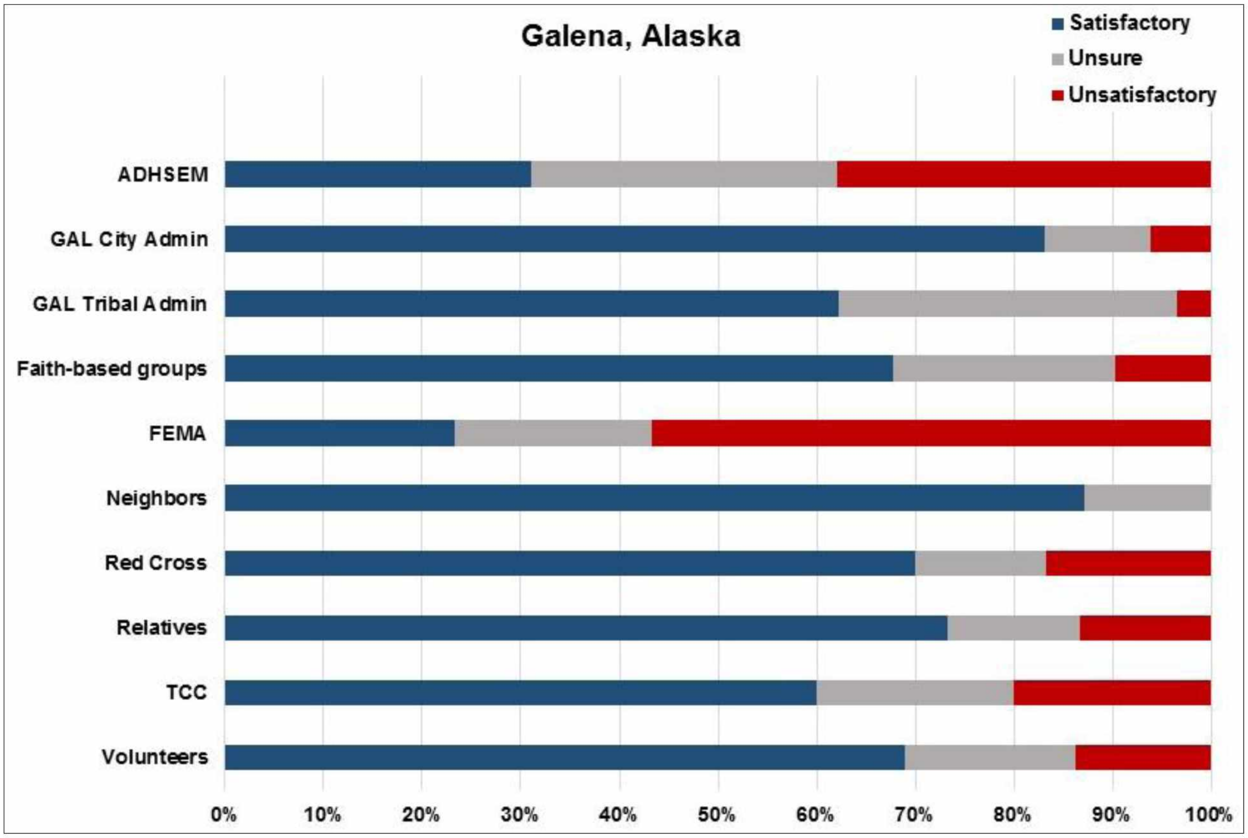

Figure 4. 7 Comparative Chart of Assistance Efforts in Galena. Evaluation of assistance efforts received by the impacted population during and after the 2013 flood in Galena.

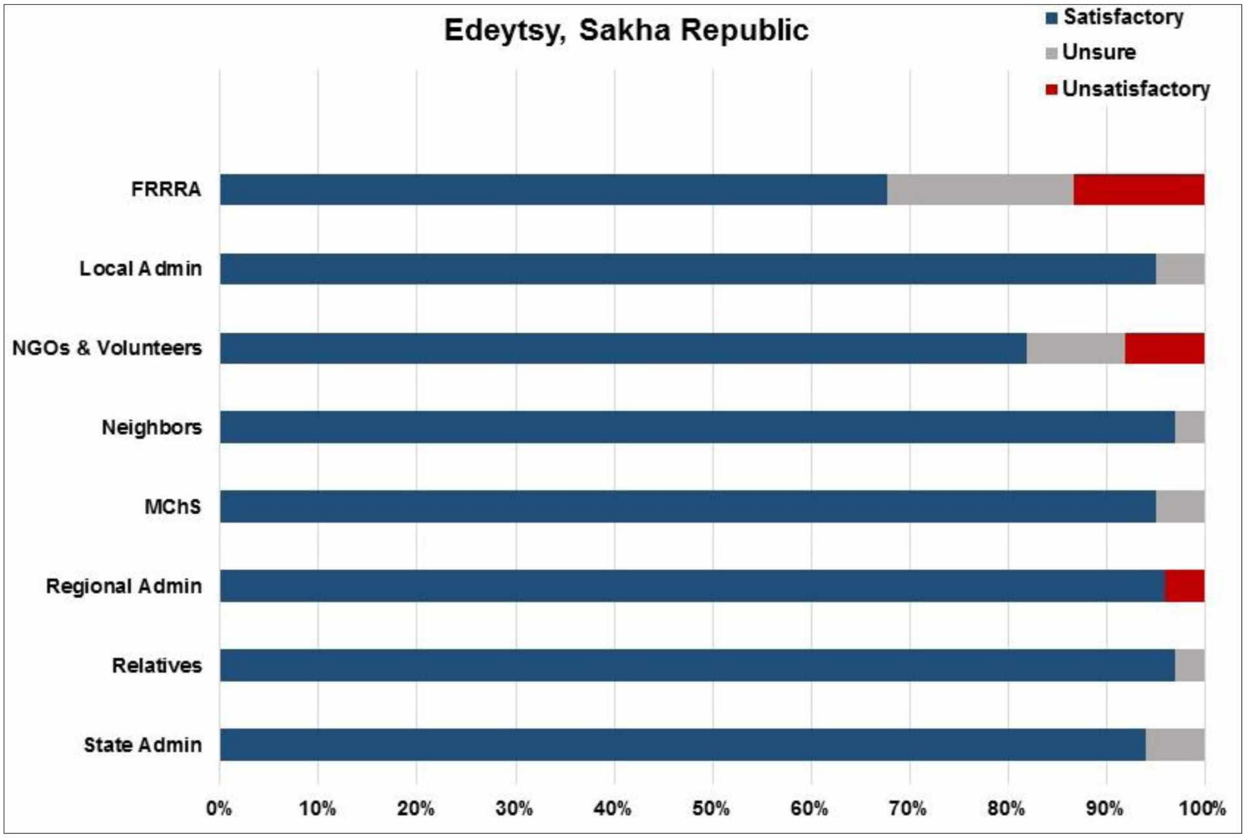

Figure 4. 8 Comparative Chart of Assistance Efforts in Edeytsy. Evaluation of assistance efforts during and after the 2013 flood in Edeytsy.

Survey results also depict Galena and Edeytsy residents as well aware and informed about immediate flood risks; residents in both communities actively monitor the breakup (Figure 4.9). In Edeytsy, 83% of survey respondents regularly monitor breakups and seek flood-related information through state television and radio broadcasts, internet sources (e.g., LBWM official site), as well as relatives and friends that reside in communities upstream. In Galena, over 96% of survey respondents regularly monitor breakups and seek flood-related information via radio broadcasts, relatives and friends from upstream communities, and the interactive breakup map available on the Alaska-Pacific River Forecast Center (RFC) website.

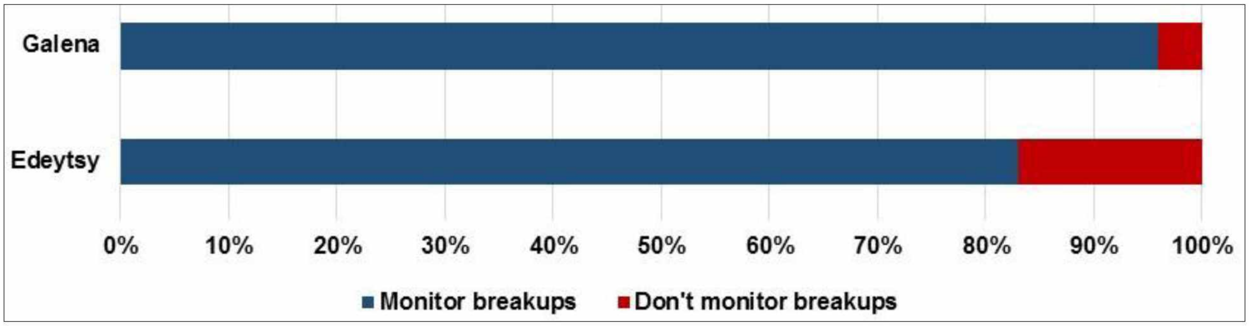

Figure 4. 9 Breakup Monitoring in Galena and Edeytsy. Comparative chart of breakup monitoring rating among population at risk in both communities.

The high statistic of breakup and flood monitoring in both communities may be attributed to the high level of flood awareness due to the recent occurrence of the catastrophic floods. On the other hand, the numbers might reflect that breakup is an exciting time in rural northern communities, which foreshadows the long-awaited arrival of spring, while also portending floods (Pelkola & Korta, 2015; Yadreev, 2016).

Survey responses and focus group discussions revealed that timely and accurate flood warnings and effective local leadership played crucial roles in reducing exposure of Galena and Edeytsy residents to the 2013 floods. As a rule, the local administration in Galena and Edeytsy receive up-to-date breakup forecasts and flood warnings from the National Weather Service (NWS) and Roshydromet respectively. The communities' leaders disseminate the relevant information further, via personal communication, radio, or social media, thus raising awareness about the potential floods (Alaska-Pacific River Forecast Center [RFC], n.d.; Androsov, 2015; Pelkola & Korta, 2015; Taylor et al., 2016; Yadreev, 2016). It appears that the NWS and Roshydromet practice the social network contagion communication approach by developing partnerships with the communities' leaders, who further convey the message to the rest of the at-risk population (Lundgren & McMaking, 2009).

Despite the attempts to reduce exposure prior to the flood in May 2013, Galena and Edeytsy suffered severe negative impacts. Floodwaters and ice floes damaged or destroyed nearly all residences and infrastructure in both communities. In addition to their homes, hundreds of residents lost their seasonal and annual income. In Edeytsy, a predominantly agricultural and cattle-ranching society, farms and pasturelands sustained the biggest damage. Within two weeks, the floodwaters destroyed over 60% of arable land (Yadreev, 2015). As a result, the autumn harvest was low, and most residents suffered financial loses.

A dual economy, which incorporates cash and subsistence segments, prevails in Galena. The wellbeing of most residents depends on the permanent access to hunting and fishing grounds, which was limited after the flood. Over half of the survey respondents noted losing freezers that contained their game and fish stocks. Unable to replenish them in a timely manner, Galena residents suffered additional financial losses (Taylor et al., 2016; Kontar et al., in press).

Besides Galena and Edeytsy, multiple riverine communities in Alaska and the Sakha Republic are exposed to spring floods due to their location. In the Sakha Republic, 222 communities (approximately 630 thousand people) out of 409 are located in floodplains and exposed to ice jam floods (Lepchikov, 2013 as cited in Gavrilyeva et al., in press). Ninety-five communities (43%) regularly experience spring floods. According to the Alaska-Pacific River Forecast Center, 45 Alaskan communities (populations ranging between 40-500 people) out of 356 are exposed to spring floods (RFC, 2016).

Growth in exposure is one of the principal drivers of increasing disaster risk. When it is not possible to avoid exposure to natural hazards, disaster risk may be mitigated through structural and non-structural methods. At the same time, exposed communities and individuals face disaster risk only to the extent of their vulnerability (IPCC, 2012; UNISDR, 2015). While everyone in a community could be exposed to a hazard, not everyone would be vulnerable.

4.3 Vulnerability Progression in Edeytsy and Galena

The forgoing content characterized vulnerability as the human dimension of disaster. Vulnerability is a defining component of flood risk, which represents a range of economic, political, institutional, environmental, and social factors that makes a community susceptible to spring floods (e.g., Blaikie et al., 1994; Birkmann, 2006; Wisner et al., 2012; IPCC, 2014; UNISDR, 2015). These factors are dynamic as they are driven and altered by events and policies from local to global levels (Twigg, 2004; Wisner et al., 2004; GFDRR, 2014; Cutter et al., 2015). To distinguish best strategies in reducing flood risk in Galena and Edeytsy, I identified and assessed vulnerability factors in both communities.

Due to its complexity and multidimensionality, vulnerability cannot be reduced to a single metric (unless it is regarded strictly as value of built environment and number of lives exposed to extreme event), and thus cannot be easily quantified (Adger, 2006). For this reason, vulnerability analysis is predominantly qualitative. In practice, vulnerability analysis focuses exclusively on either a population's physical vulnerability, or socioeconomic vulnerability. Disaster scholars, however, argue that vulnerability analysis should ideally be holistic and incorporate the following three key factors: 1) physical exposure and susceptibility of a population to hazards, 2) lack of disaster resilience, and 3) fragility of the socioeconomic systems (e.g., Blaikie et al., 1994, Cardona 2004; Birkmann, 2006; Cutter et al., 2015).

I implemented the Pressure and Release (PAR) disaster model to conduct a comprehensive vulnerability analysis for the two case studies (Figure 2.6). The PAR model allowed me to track the chain of vulnerability causes, from the underlying drivers (e.g., socioeconomic processes) to the immediate dangerous conditions (e.g., poorly constructed houses). As pointed out by Turner et al. (2003), the PAR model directs attention to the conditions that make a population's exposure to a hazard unsafe, leading to vulnerability and the causes that have created these conditions. By implementing the PAR model, I identified the progression of vulnerability that has been driving the flood risk in Galena and Edeytsy.

Historical analysis of spring floods in Galena and Edeytsy point to common root causes between the two research sites, including colonial heritage, unequal distribution of resources and power, top-down governance, and limited inclusion of local communities into the decision making process (Figure 4.10, Figure 4.11). As described in the Introduction chapter, Galena and Edeytsy were formed into permanent settlements rather abruptly by their state governments in the first half of the 20th century. Neither local population, nor local knowledge about ice-jam floods were factored into the original decision-making processes.

Although pursuing different underlying goals (e.g., establishment of kolkhoz in Edeytsy and an ore-mining base and later a USAF base in Galena), state governments in Alaska and the Sakha Republic similarly focused on rapid community settlement and expansion. The original absence of flood risk governance resulted in a lack of building codes, and flood prevention, mitigation, and preparedness measures. For decades, flood-ravaged houses in Galena and Edeytsy were quickly rebuilt on the same places with no intent to reduce the populations' exposure and vulnerability to spring floods (Morgan, L., 1972; Lindenau, 1983; Arundale, 1985).

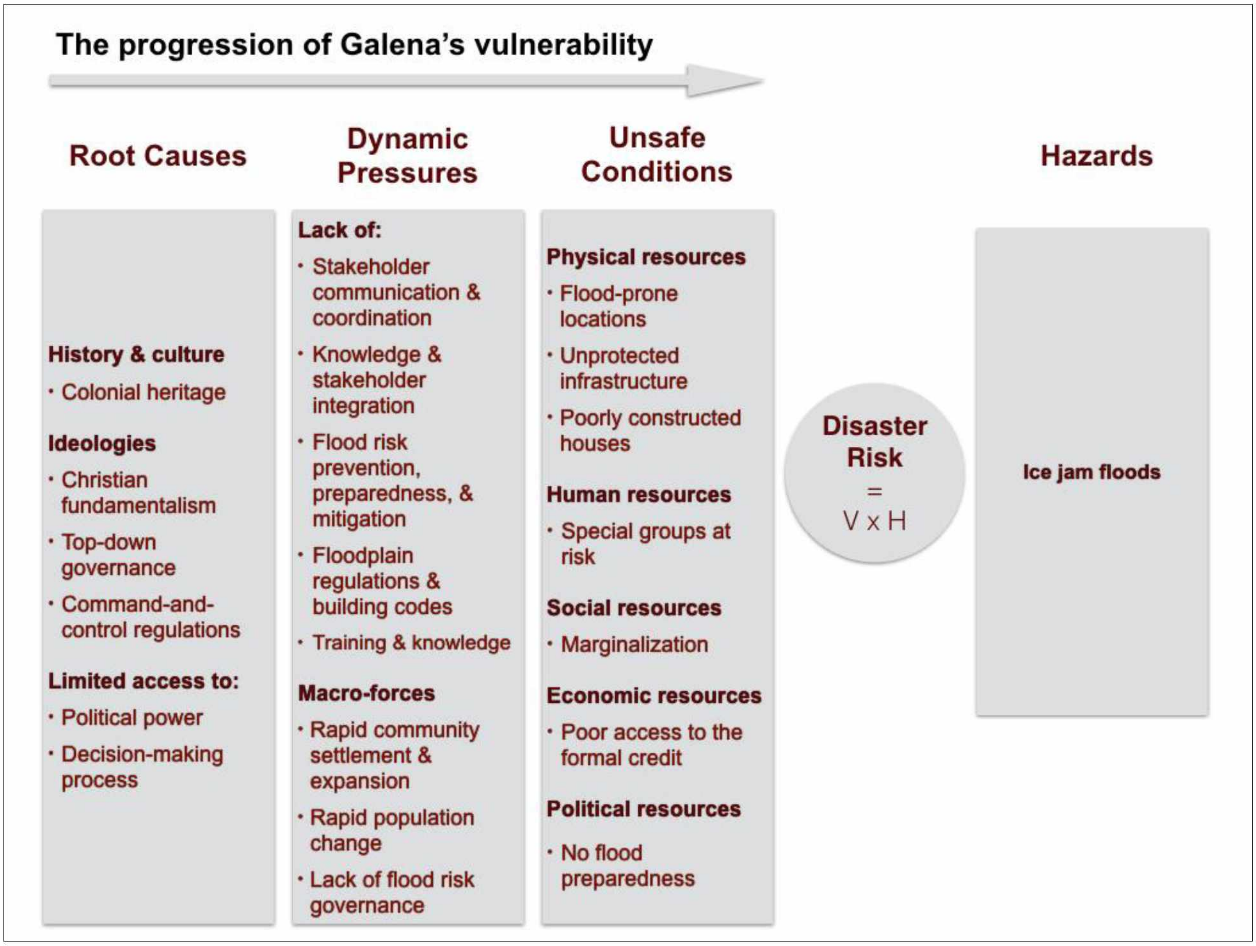

Figure 4. 10 The Progression of Galena's Vulnerability. Pressure and Release (PAR) model of spring flood disaster in Galena, Alaska. Modified from Blaikie et al., 1994.

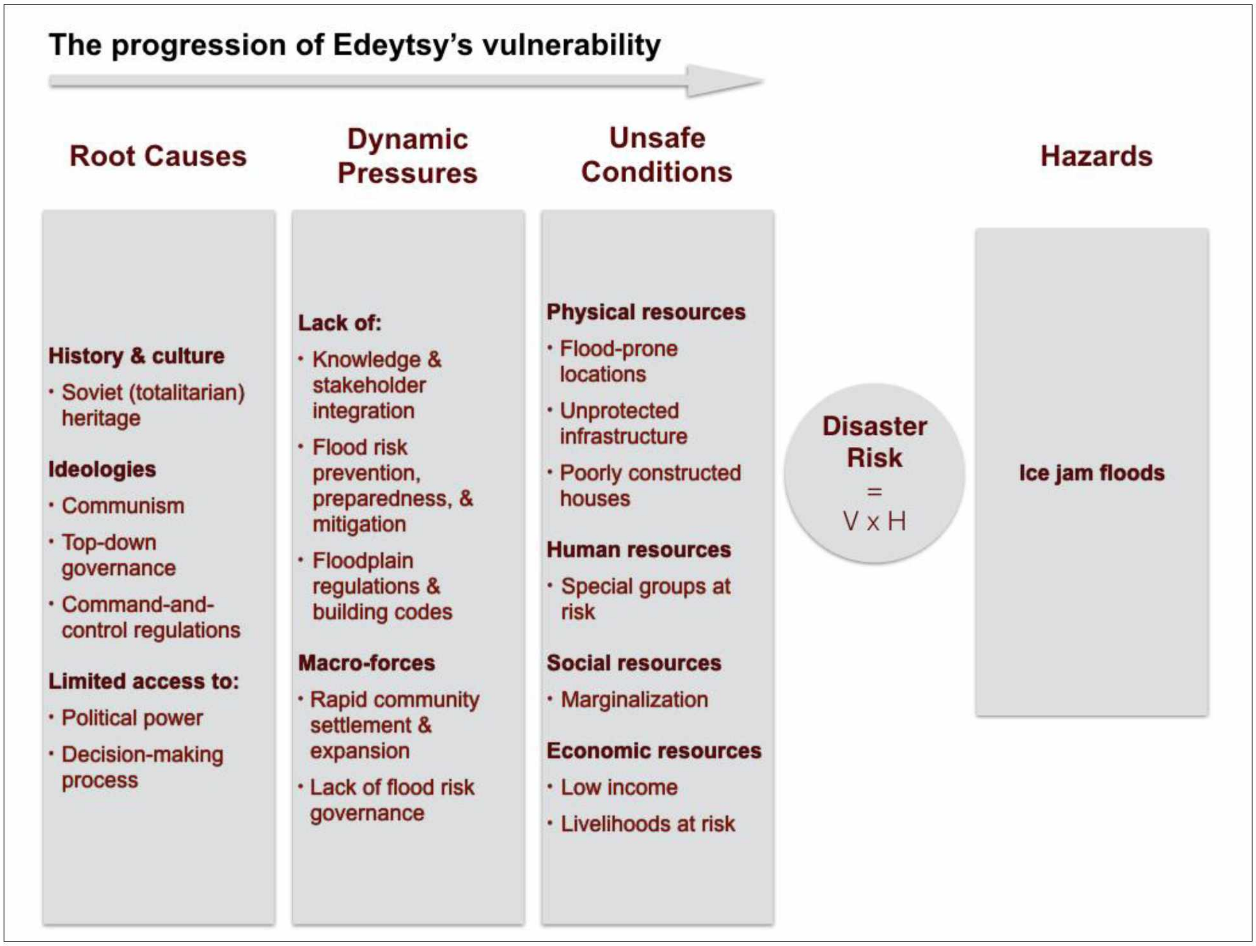

Figure 4. 11 The Progression of Edeytsy's Vulnerability. Pressure and Release (PAR) model of spring flood disaster in Edeytsy, Sakha Republic. Modified from Blaikie et al., 1994).

As Galena and Edeytsy became more strategically important by the mid 1940s, state governments began to implement flood management strategies to protect valuable state assets from the adverse impacts of spring floods. Adhering to command-and-control regulations, state governments in both regions were administering flood regulation programs at the detriment of local actions (News Miner, 1945, 1963, 1971a, 1971b; Mongin, et al., 1972; Morgan, L., 1972; Lindenau, 1983; Arundale, 1985; IFRC, 2006; Gaillard & Mercer, 2012). Galena and Edeytsy populations including the local administrations did not take part in flood management planning, but merely were tasked to relay actions from the top down (McEntire, 2007; Kontar et al., 2015). For example, a dike was constructed in Galena in 1944 to exclusively protect the base and its infrastructure, while leaving the settlement completely exposed to future floods (Figure 4.5) (Arundale, 1985; Mongin et al., 1972; Morgan, L., 1972; Sprott, 2000). The construction was funded by the USAF, and implemented by the Galena residents (Mongin et al., 1972; FEMA, 1983).

Opinions of the local population regarding relocation were not accounted for when choosing the new site's location after the flood in May 1971. For the construction of Galena's New Town, the Alaska State Housing Authority (ASHA) allocated a site near Alexander Lake approximately one mile away from Old Town. ASHA surveyed the proposed relocation site and determined that it was appropriate for relocation as "it has received very little water during this record high flood" (News Miner, 1971b). As stated in the News Miner article, *Galena flood damage may reach $2 million*, "…villagers felt the [proposed relocation] site was too low…. and [thus] wanted to move the village onto high ground on the Campion site, … but it was unlikely federal approval could be obtained for such a move" (News Miner, 1971b). At the time, the Campion site was the USAF dumpsite. The Campion site remained dry during all flood years, including 2013 (Denver, 2016; Korta, 2016).

Initially, flood management in the Sakha Republic has solely involved mechanical and short-term measures, such as ice cutting, weakening, and demolishing. Focusing primarily on reducing the hazard, the state government had been neglecting the underlying causes of the at-risk community's vulnerability. As the villages, such as Edeytsy, were continuously rebuilt on the same place, their vulnerability remained or even increased along with the population numbers (Lindenau, 1983; Vakhtin, 1992).

As mentioned above, mechanical ice jam mitigation efforts are proactive, but not necessary effective (Buzin, 2004; Burrell et al., 2015). The methods were designed according to hydrological models developed by university and state scientists (Buzin, 2004; Buzin et al., 2014). However, no criteria for the effectiveness of the models have yet been established (Tananaev, 2016). Therefore, there is no published evidence of these methods' effectiveness. Continuing to spend large state funds on mechanical ice jam mitigation efforts without further research of their effectiveness appears to be imprudent.

In the last two decades, more long-term flood mitigation measures (e.g., construction of dikes, elevation of buildings, and relocation) have been implemented in rural Sakha Republic. For example, the construction of a dike was initiated in Edeytsy after the flood in May 2010 (Figure 4.4). Due to incremental funding, the construction continues six years later while the community continues to face the negative impacts of spring floods. According to Yadreev (2016), the local administration views the dike and elevation of buildings as the optimal solutions for the community. However, the necessary state funds to implement these measures remain difficult to obtain. The initial integration of the local administration in the decision-making process could have prevented the unnecessary continuous expenditure of state funds on short-term mitigation efforts, and reduced the community's exposure and vulnerability through long-term mitigation efforts.

Due to the unpredictability of spring floods along with limited mitigation efforts, Galena and Edeytsy have been predominantly relying on flood relief and recovery efforts. As mentioned in the Introduction chapter, federal assistance during most disasters in Alaska and the Sakha Republic is crucial. In Alaska, the outside assistance is rarely timely. According to Pelkola and Korta (2015) and Korta (2016), most of the valuable response time after the 2013 flood was spent on a range of paperwork and approvals. To verify the warranty of the federal disaster declaration, federal agencies had to conduct additional damage assessments, thus delaying the reconstruction efforts for almost another month (Department of Homeland Security [DHS], 2014; Kontar et al., 2015; Taylor et al., 2016).

Due to more densely populated northern regions and more frequent severe spring flooding, relief and recovery efforts in Edeytsy have been implemented in a more efficient manner. Federal and state assistance often arrives from large northern hubs such as Yakutsk, which is only 50 km away from Edeytsy. Emergency personnel are trained in higher latitudes and are familiar with the unique logistical and cultural features of the northern regions (Androsov, 2015; Yadreev, 2015). Significantly higher reported satisfaction ratings in Edeytsy indicate the effectiveness of flood relief and recovery efforts in the Sakha Republic (Figure 4.12) (Gavrilyeva et al., in press; Kontar et al., in press).

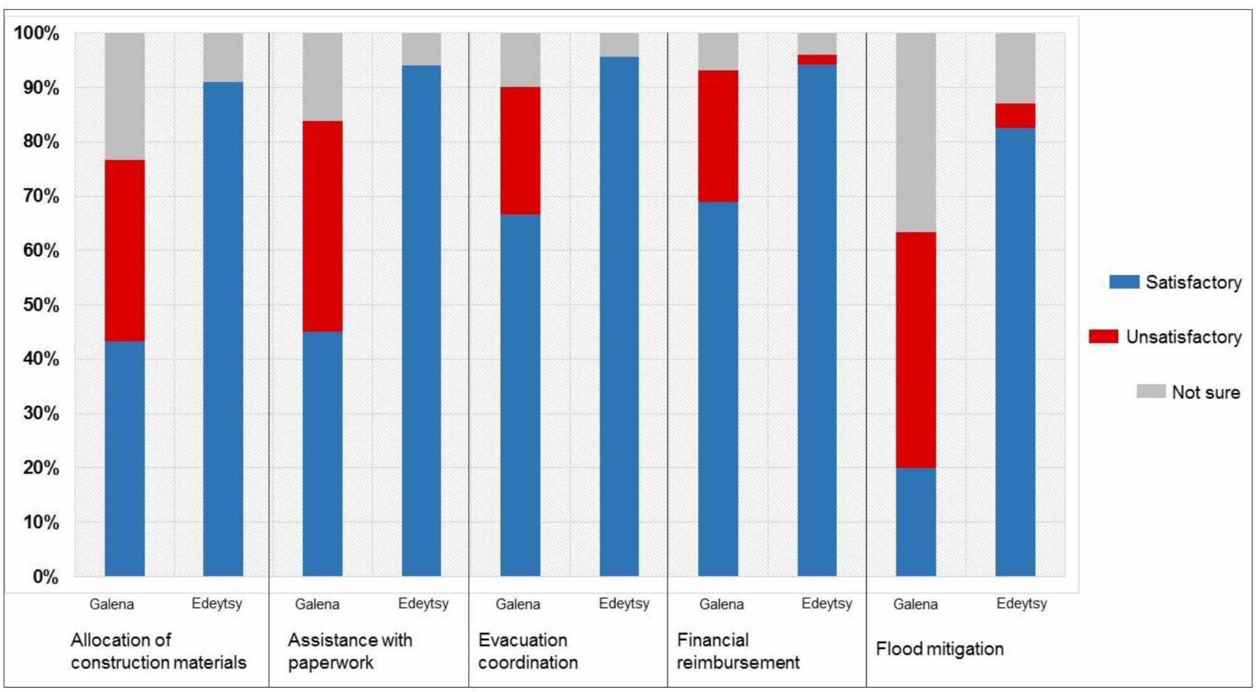

Figure 4. 12 Comparison of Flood Management Efforts. Evaluation of the effectiveness of the key flood response and recovery efforts in Galena and Edeytsy.

During the flood in May 2013, vulnerability in Edeytsy and Galena was predominantly expressed by the presence of poorly constructed houses and unprotected infrastructure in flood-prone locations. A few vulnerability factors were not immediately obvious; for example, special risk groups who are more susceptible to flooding, but their vulnerability is not accounted for in contingency planning (Wisner et al., 2012). For instance, vulnerability of the Galena's elder home residents was not accounted for in flood preparedness measures in May 2013. According to Pelkola and Korta (2015), Korta (2016), and Denver (2016), the elder home residents were the most challenging group to evacuate during the 2013 flood. Located in New Town, the elder home could only be accessed via boats. Elders, most of whom required assistance walking, were evacuated in boats to the dike through the fast-moving ice floes, and then on a bus to the shelter. The elders later had to be evacuated further to their relatives, in nearby communities or as far as Fairbanks and Anchorage.

As a rule, special at-risk groups in Edeytsy, such as elders and children, are relocated to relatives and friends in other communities at least two or three days prior to the potential flood (Androsov, 2015; Yadreev, 2016). Flood preparedness and contingency planning was significantly improved in Edeytsy after the flood in May 2010, when most residents lost their cattle. As previously discussed, Edeytsy is a predominantly cattle ranching and farming community. Spring floods put these livelihoods at risk. Edeytsy residents preserve their livelihoods by relocating the cattle and farm machinery to higher ground at least two days prior to the potential flood; however, farm lands remain exposed to spring floods.

Disaster research over the past three decades has revealed that the poor and marginalized members of society suffer disasters worst and more frequently (Twigg, 2004; UNISDR, 2009; Wisner et al., 2012; Sendai Framework, 2015). Historical analysis revealed that the indigenous population in Galena had suffered impacts of breakup floods worse than the USAF staff and other non-native Galena residents (e.g., News Miner, 1945, 1963, 1971a, 1971b; Morgan, L., 1972; Arundale, 1985).

In her feature story on the impacts of the 1971 flood *Galena—how to win a flood*, Lael Morgan depicted the preferential treatment toward the non-native population during flood relief efforts: “Three days later the refugees were still camped on the dike waiting for the water to recede. They were short of food … although they’d been visited by the Governor, Secretary of the Air Force, the Red Cross and numerous tourists — no one had offered them so much as a cup of soup.” A News Miner article from May 24, 1971 provided a contrasting description of flood assistance efforts to the USAF staff: “… 200 men stationed at the Galena air base were evacuated to the Campion [site]… although water did not reach the top of the dike surrounding the base. …Campion was well stocked with supplies… coats, blankets, tents, and food” (News Miner, 1971a). Establishment and expansion of Tribal governance in Alaska minimized marginalization of the native population during floods (Pelkola & Korta, 2015; K. Wright, personal communication, March 14, 2016).

Implementing the PAR model to analyze the vulnerability progression of Edeytsy and Galena has demonstrated that the vulnerability of both communities is deeply rooted in socio-economic and political processes. It was built up over decades of top down regulations and insufficient flood risk governance. Reducing vulnerability in both communities is a crucial part of reducing flood risk. Reducing vulnerability is only plausible through the reduction of the underlying political, economic, and social drivers of vulnerability. Analysis revealed the initial lack of local knowledge and integration of local communities in the decision-making processes regarding flood management as the key underlying driver of vulnerability in both regions.

5. Spring Flood Risk Reduction in Alaska and the Sakha Republic

As discussed in the previous chapter, spring flood risk in Galena and Edeytsy has resulted from complex interactions between a series of natural processes and human actions that generated conditions of hazard (i.e., spring floods), exposure, and vulnerability (Twigg, 2004; IPCC, 2012; GFDRR, 2014; Gavrilyeva et al., in press; Kontar et al., in press). Therefore, flood risk in Galena and Edeytsy can be reduced by managing conditions of ice-jam floods, and decreasing exposure and vulnerability of the at-risk populations (GFDRR, 2014; UNISDR, 2015; Kontar et al., in press).

Flood risk reduction incorporates the development, application, and evaluation of policies, strategies, and practices to reduce or eliminate adverse flood impacts in at-risk communities (IPCC, 2012; UNISDR, 2015). *Flood risk management* implies specific means and actions necessary to achieve the objectives of reducing flood risk (UNISDR, 2015). Flood risk management falls into three main pre-disaster phases: prevention, mitigation, and preparedness (Figure 2.7), which are based on the assumption that the hazard (i.e., spring floods) will reoccur (Twigg, 2004; Wisner et al., 2012; UNISDR, 2015). Thus, the main goal of flood risk management is to reduce, or ideally eliminate the adverse impacts of future spring floods.

Via a comparative analysis between Galena and Edeytsy, I summarize the existing flood risk management practices in Alaska and the Sakha Republic, and identify their strengths and weaknesses in terms of reported satisfaction. I also analyze the cross-national applicability of the best practices in flood risk management in both regions. Analysis of the vulnerability progression of Galena and Edeytsy revealed that the initial lack of integration of local populations and their knowledge into the decision-making process regarding the communities' development is the mutual key underlying driver of the flood risk. Hence, I focus my analysis on stakeholder communication and collaboration as an integral part of flood risk reduction in Alaska and the Sakha Republic.

5.1 Comparative Analysis of Spring Flood Prevention and Mitigation Efforts

Although often used interchangeably, flood mitigation and flood prevention are not synonyms. Flood mitigation refers to lessening the adverse impacts of floods through a range of structural and non-structural measures (e.g. construction of dikes or enforcement of building codes), while flood prevention refers to the complete avoidance of adverse flood impacts (e.g., full community relocation) (Belore et al., 1990; UNISDR. 2007; IPCC, 2014).

Unlike most natural disasters, opportunities for reducing spring flood risk lie not only in reducing vulnerability and exposure of the at-risk population, but also in reducing the severity of the hazard itself (Kontar & Trainor, 2016; Kontar et al., in press). Throughout history, an array of ice jam prevention and mitigation measures have been implemented in the US and Russian North with varying degrees of success (e.g., Belore et al., 1990; Kusatov et al., 2012; Buzin et al., 2014; Burrell et al., 2015; Kontar et al., 2016; Gavrilyeva et al., in press).

Every mitigation and prevention technique has potential benefits and drawbacks (Table 5.1). The selection of a particular mitigation technique or a combination of techniques should depend not only upon the availability of resources and time, but also the careful analysis of the causative factors of ice jams and unique geographic, geological, and morphological features of the river channel and the floodplain (Belore et al., 1990; Buzin et al., 2014; Burrell et al., 2015). The history of floodplain management and progression of a population's vulnerability to floods, along with regional environmental constraints should also be included in the analysis (Belore et al., 1990; Kusatov et al., 2012; Kontar et al., in press).

Table 5. 1 Spring Flood Mitigation Strategies. The table lists the existing ice jam flood mitigation and prevention techniques in Alaska and the Sakha Republic, and their potential positive and negative impacts.

Ice Jam Prevention			
Technique	**Description & Function**	**Region**	**Drawbacks**
Ice dusting/sanding	Spreading a thin layer of a dark solid substance (e.g., coal) to promote the deterioration of an ice cover by decreasing the albedo of the ice, and thus increasing its melting rate.	Sakha	• Often ineffective due to fresh snow covering dusted areas, or new periods of freezing. • Not effective in persistently cloudy regions. • Possible water and soil contamination. • No statistical evidence of effectiveness.
Blasting (pre-breakup)	Fracturing ice cover to promote early release of small ice floes prior to high spring flow.	Sakha	• Expensive. • Dangerous for practitioners. • Negative environmental impacts. • No statistical evidence of effectiveness.
Ice cutting (saws)	Creating lines of weakness to promote deterioration of ice cover and release of stationary ice prior to high spring flow. Decreasing size of ice floes to promote release and flow of ice.	Sakha	• No statistical evidence of effectiveness.
Flood Impact Reduction			
Technique	**Description & Function**	**Region**	**Drawbacks**
Floodplain MGMT	Prevention/discouragements of communities in flood-prone areas.	Alaska Sakha	Can lead to interagency and intergovernmental conflicts.
Flood-proofing • Dikes • Elevation of structures	Construction of dikes to confine streamflow to the river channel, thus to protect infrastructure and homes from inundation and ice debris damage. Corrective elevation of existing structures or preventative elevation of new structures to a height above the largest flood to date.	Alaska Sakha	These structural measures require large initial investments and, in some cases, continuous future investments for after-flood repairs and maintenance.
Relocation	Partial or full relocation of the at-risk communities away from the floodplain.	Alaska Sakha	• If relocation is imposed on communities, it is often unsuccessful because residents tend to return to their original settlements. • Disaster assistance funds often exclude money for preventive measures.
Flood forecasting and EWS	Predicting timing, duration, and magnitude of water level rise. Encouraging timely evacuation of people, their assets, and cattle to prevent life loss and minimize flood damage.	Alaska Sakha	Inaccurate forecasts could lead to unnecessary evacuations, and hence discourage further future evacuation.
Blasting (ice jam removal)	Release already formed ice jams by fracturing ice cover.	Sakha	• Expensive. • Dangerous for the practitioners. • Negative environmental impacts. • No statistical evidence of effectiveness.

The analysis of focus group discussions with US and Russian representatives from the agencies responsible for flood risk management (Table 1.2, Table 1.3) revealed two key categories of ice jam flood prevention and mitigation strategies in Alaska and the Sakha Republic (Table 5.1):

1. *Ice jam prevention*: preventive measures to eliminate or lessen the likelihood of a damaging ice jam event from occurring.
2. *Reduction of ice jam flood impact*: preventive measures to reduce the potential adverse impacts from floodwater and ice floes. These measures are further divided into structural and nonstructural.

Since Galena's establishment in the early 1920s until 1972, the airport was the only part of Galena that was protected from spring floods. After the flood in May 1944, a dike was built to protect the airport and the USAF base (Mongin et al., 1972). The community itself, however, was left exposed to floods (Figure 4.5). To protect Galena residents from spring floods, the USAF demolition teams had attempted to dislodge stubborn ice jams at the Bishop Rock by placing explosive charges under the ice (Arundale, 1985; Mongin et al., 1972 as cited in Kontar et al., 2015; Denver, 2016). As stated in the Alaskan Air Command's report, the demolition efforts were proven ineffective and were discontinued in 1970 (Mongin et al, 1972). According to photographic evidence, ice dusting mitigation efforts were implemented along the Yukon River near Galena and other communities in Interior Alaska (Figure 5.1) (Plumb, 2015; Denver, 2016). Despite extensive research, no detailed record of the exact timeframe or effectiveness of these efforts was located (S. Nelsen & D. Lee, personal communication, June 14, 2016).

Figure 5. 1 Ice Jam Mitigation in Interior Alaska. Photographs depict river ice sanding operations along the Yukon River in 1980s. Modified from Denver, 2016.

After the 1971 flood (the largest spring flood to date), an area called New Town was constructed approximately one mile upriver with the goal to relocate Galena's residents on higher ground, further from the floodplain (Kontar et al., 2015). New Town remained a flood-resilient location for four decades, until it was ravaged by floodwater and ice floes in May 2013 (Pelkola & Korta, 2015; Kontar et al., 2015; Taylor et al., 2016).

In Edeytsy, a combination of structural and mechanical mitigation techniques were implemented prior to and during the flood in May 2013. With financial support from the State (Republic) government, the construction of a dike was initiated after the breakup flood in May 2010 (Figure 4.4). Due to incremental funding, construction of the dike was not completed prior to the flood in May 2013 and is still ongoing (Yadreev, 2016).

A series of mechanical mitigation efforts, including ice jam dusting, cutting, and blasting have been implemented continuously for two decades to protect Edeytsy and other riverine communities, both rural and urban, from spring floods (Figure 5.2, Table 5.1) (Buzin et al., 2014; Androsov, 2015; Bykov, 2015; Platonov, 2015; Yadreev, 2016). As mentioned above, the state administration also allocates housing certificates to the residents whose houses are prone to flood damage encourage community relocation from the floodplain as a mitigation effort (OECD, 2015; Yadreev, 2015).

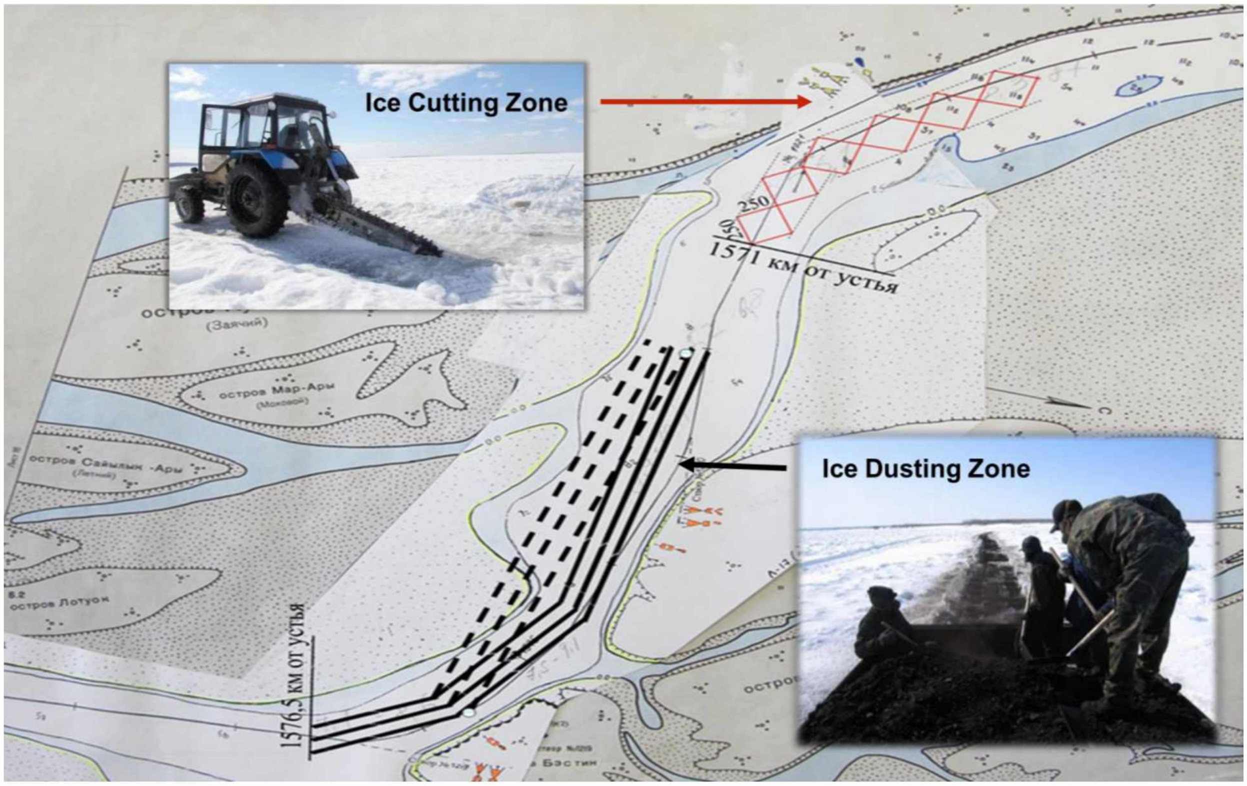

Figure 5. 2 Ice Jam Mitigation in Central Sakha Republic. Map of river ice cutting and dusting operations on the Lena River near At-Ary and Edeytsy, the Sakha Republic. Modified from Yadreev, 2015.

Despite the aforementioned flood mitigation efforts, the 2013 floods caused severe adverse impacts in Galena and Edeytsy, including extensive damage and destruction of infrastructure, houses, and movable assets, along with the loss of services and means of livelihoods (Kontar et al., 2015; Taylor et al., 2016; Gavrilyeva et al., in press). New structural measures were initiated in both communities to enhance spring flood mitigation.

As part of enhanced flood mitigation, most of the houses in Galena's New Town and a few houses in Edeytsy were elevated (Korta, 2016; Yadreev, 2016). In Galena, 44 (out of 54) houses that sustained flood damage in May 2013 were elevated on steel pilings approximately one foot above the highest flood mark of 135.5 feet (Figure 5.3) (Aecom Technology Corporation [AECOM], 2014; Denver, 2016; Korta, 2016). Designed to protect New Town residents, their houses, and assets from future floods, most houses were elevated too high for the elder residents, and ruin the visual aesthetic of the town (Pelkola & Korta, 2015).

Figure 5. 3 Rebuilding Galena. (left) A Galena bed-and-breakfast inundated with ice debris, May 2013. Modified from Plumb, 2015; (right) the same bed-and-breakfast rebuilt on steel pilings, June 2014. Modified from D. Lee, personal communication, May 4, 2016.

Figure 5. 4 Reconstruction in Galena. Volunteers completing the construction of a replacement house according to the CCHRC guidelines, June 2014. Each house took around two months to complete. Modified from Hébert, 2016.

The flood recovery was also an opportunity for sustainable development in Galena. The Cold Climate Housing Research Center (CCHRC) collaborated with the FEMA and ADHSEM to develop six energy-efficient and affordable replacement housing units for Galena residents (Figure 5.4) (Hébert, 2016). The houses were developed specifically for Galena. The construction materials are easy to transport and assemble. The floor, walls, and roof are combined into single pre-built trusses that can be easily tipped up (Cold Climate Housing Research Center [CCHRC], n.d.; Hébert, 2016). Easy and rapid assembly is an important factor, because a large portion of reconstruction in rural Alaska has to be completed in a short period of time with help from volunteers, who might not have the necessary labor skills. The houses contain 10 inches of polyurethane spray foam insulation, which is airtight and moisture resistant, and thus critical for maintaining dry and mold-free walls. The foam is also an economical option for Galena and other remote Alaskan villages because of its low shipping costs and high R-value (CCHRC, n.d.; Hébert, 2016).

Although only six houses in Galena were reconstructed according to the resilient design described above, it was a step towards the sustainable development of rural Alaska. Galena is part of a larger project with the state to create a matrix of approaches that can be used for emergency replacement housing (CCHRC, n.d.; Hébert, 2016). As stated in the Sendai Framework and echoed by the disaster research community, sustainable and resilient development is an integral part of disaster risk reduction (Cutter et al., 2015; Sendai Framework, 2015).

In Edeytsy, six houses were elevated on wooden pilings (Figure 5.5) (Yadreev, 2016). An effective mitigation technique in regular floods, wood pilings have proven to be unreliable at withstanding ice damage (Belore et al., 1990; Buzin et al., 2014). The elevated houses are located in the part of the village that received little to no ice damage (Yadreev, 2016). According to Edeytsy local administration, a completed dike, elevated houses, and continuous short-term mitigation efforts (e.g., ice jam blasting and dusting) should protect Edeytsy from future spring floods (Yadreev, 2016).

Figure 5. 5 Reconstruction in Edeytsy. A house in Edeytsy that was rebuilt on wood pilings after the flood in May 2013. Photo: John Eichelberger, University of Alaska Fairbanks.

Mechanical ice jam mitigation techniques (e.g., ice jam breaching and removal) are more proactive, but not necessarily effective (Kontar et al., in press). These techniques are designed according to hydrological models developed by academic and state scientists; however, no criteria for the effectiveness of these models have yet been established (Kusatov et al., 2012; Buzin et al., 2014; Tananaev, 2016). Therefore, there is no published evidence of these methods' effectiveness. According to Androsov (2015), over 52 thousand dollars were invested in ice cutting and dusting measures along the Lena River in spring 2013. Yet, the breakup resulted in significant flooding.

Nevertheless, survey results revealed a higher satisfaction rating with the mitigation and prevention measures among Edeytsy residents (Figure 4.12). During participant observations, I also noted disappointment among the residents in Galena and other rural riverine communities in Alaska regarding the absence of short-term ice-jam mitigation efforts. Watching their communities ravaged by ice floes, people hoped for prevention efforts. Overall, advances in ice jam and flood risk mitigation would improve the overall flood risk reduction in both regions. In addition to the placebo effect, short-term mitigation efforts might help reduce or even eliminate adverse impacts of spring floods. However, further comparative analysis is needed to determine the costs, benefits, and effectiveness of the mechanical ice jam mitigation efforts.

5.2 Comparative Analysis of Spring Flood Preparedness Efforts

Despite mitigation measures, in most cases, some people and property remain vulnerable to floods. Thus, flood preparedness is an integral component of flood risk reduction (UNISDR & UNOCHA, 2008; IPCC, 2014). Flood preparedness encompasses activities that increase a population's ability to predict, prepare for, as well as respond to and recover from disasters (UNISDR, 2007; IPCC, 2014). Preparedness, similarly to mitigation, is a pre-disaster measure, which is aimed at protecting a population before a flood strikes. During the 2013 floods, preparedness measures in Galena and Edeytsy included early warning, evacuation of at-risk population and livestock to higher ground, and facilitation of rapid response (Gavrilyeva et al., in press; Kontar et al. in press).

As previously mentioned, a large portion of Galena's population has not experienced a major ice-jam flood in their lifetime, and thus developed a false sense of security. Caught off guard by the severity of the 2013 flood, most Galena residents did not take precautionary measures to protect their houses, movable assets, and animals (Korta, 2016). The floodwater and ice floes inundated the entire community within a few hours, leaving little to no time to assist the population at risk with evacuation efforts. Nevertheless, all residents at risk were evacuated to the former USAF base, which is protected by a dike. Most residents lost their dog teams and other animals (Figure 5.6) (Pelkola & Korta, 2015). The majority of rescued dogs were transferred to animal shelters in Fairbanks and Anchorage. Either preoccupied with rebuilding and recovery, or being in long-term evacuation, Galena residents were unable to afford to take care of their animals. As noted by Taylor et al. (2016), dogs are more than pets in rural Alaska; they provide transportation and security, and have a long history of cultural significance.

Figure 5. 6 Dog Recue in Galena. (left) Galena's lifetime resident Paddy Nolner evacuating his dog team in Galena, May 2013. Modified from Plumb, 2015; (right) a dog-crossing warning sign in front of a flooded dog yard. Modified from Pelkola & Korta, 2015.

Experienced with more frequent severe flooding, Edeytsy residents were more proactive in relocating their cattle, farm equipment, and personal vehicles to higher ground. According to the survey results, over 90 percent of Edeytsy respondents avoided losses beyond their houses and outbuildings, while over half of Galena's respondents reported additional losses of vehicles and machinery (Kontar et al., 2016). The Edeytsy administration begins flood preparations a week prior to potential flooding, thus assuring that special groups at risk (e.g., elderly, children, and disabled) received the necessary assistance, and livestock had been relocated to higher ground.

As a rule, the administration in each community receives regular and timely breakup forecasts and flood warnings (Korta, 2016; Yadreev, 2016). Focus group discussions revealed that the agencies responsible for flood risk and crisis management in both regions adhere to the social network contagion theory by developing partnerships with the social leaders in the at-risk communities, who convey flood-relevant information to the rest of the population (Lundgren & McMackin, 2009; Androsov, 2015; Plumb, 2015; Yadreev, 2015; Denver, 2016). Survey responses indicated that residents in both communities regularly monitor the breakup, and seek flood-related information via governmental as well as personal sources (Figure 4.9) (Kontar et al., 2016).

The administration in Edeytsy receives breakup forecasts and flood warnings from Roshydromet, and evacuation warnings from MChS (Table 1.3) (Androsov, 2015; Kusatov, 2015; Yadreev, 2016). The administration in Galena receives regular breakup forecasts from NWS hydrologists, and flood warnings from the Alaska River Watch Team, which includes NWS hydrologists and ADHSEM emergency managers (Plumb, 2015; Korta, 2016; Denver, 2016). Although the River Watch team provided Galena with the timely flood warning, the community was not ready to withstand the 2013 flood due to a lack of preparedness (Pelkola & Korta, 2015; Korta, 2016). The local administration requested outside assistance; incremental assistance was provided by a range of state and tribal agencies and NGOs, foremost the TCC, and later by the ADHSEM and FEMA (Table 1.3). In Edeytsy, flood assistance was provided immediately due to well-established interagency communication and collaboration (Androsov, 2015; Yadreev, 2016).

As revealed by the review of academic literature and practitioners' reports, to be effective, flood preparedness must be based on a sound analysis of flood risks and detailed contingency plans, and be well linked to early warning systems (UNISDR & UNOCHA, 2008; IFRC, 2000; Wisner et al., 2012; Cutter et al., 2015). During the 2013 flood, Galena lacked a contingency plan that included New Town. The new and inclusive contingency plan was approved during a pre-breakup 2014 community meeting (Pelkola & Korta, 2015). A copy of the plan is attached in Appendix C. The Edeytsy administration advanced their contingency plan after losing a substantial portion of cattle during the ice-jam flood in May 2010 (Yadreev, 2015).

5.3 Comparative Analysis of Spring Flood Risk Management Frameworks

In Alaska and the Sakha Republic, multiple stakeholders from federal, state, and local governmental agencies, as well as NGOs and the private sector engage in spring flood risk reduction (Table 1.2, Table 1.3). In the Sakha Republic, coordination of breakup flood mitigation, preparedness, response, and recovery efforts are organized at the federal level. This unified and centralized system encourages an ongoing year-round interagency communication between throughout the flood cycle (Figure 5.7) (Androsov, 2015; Platonov; 2015).

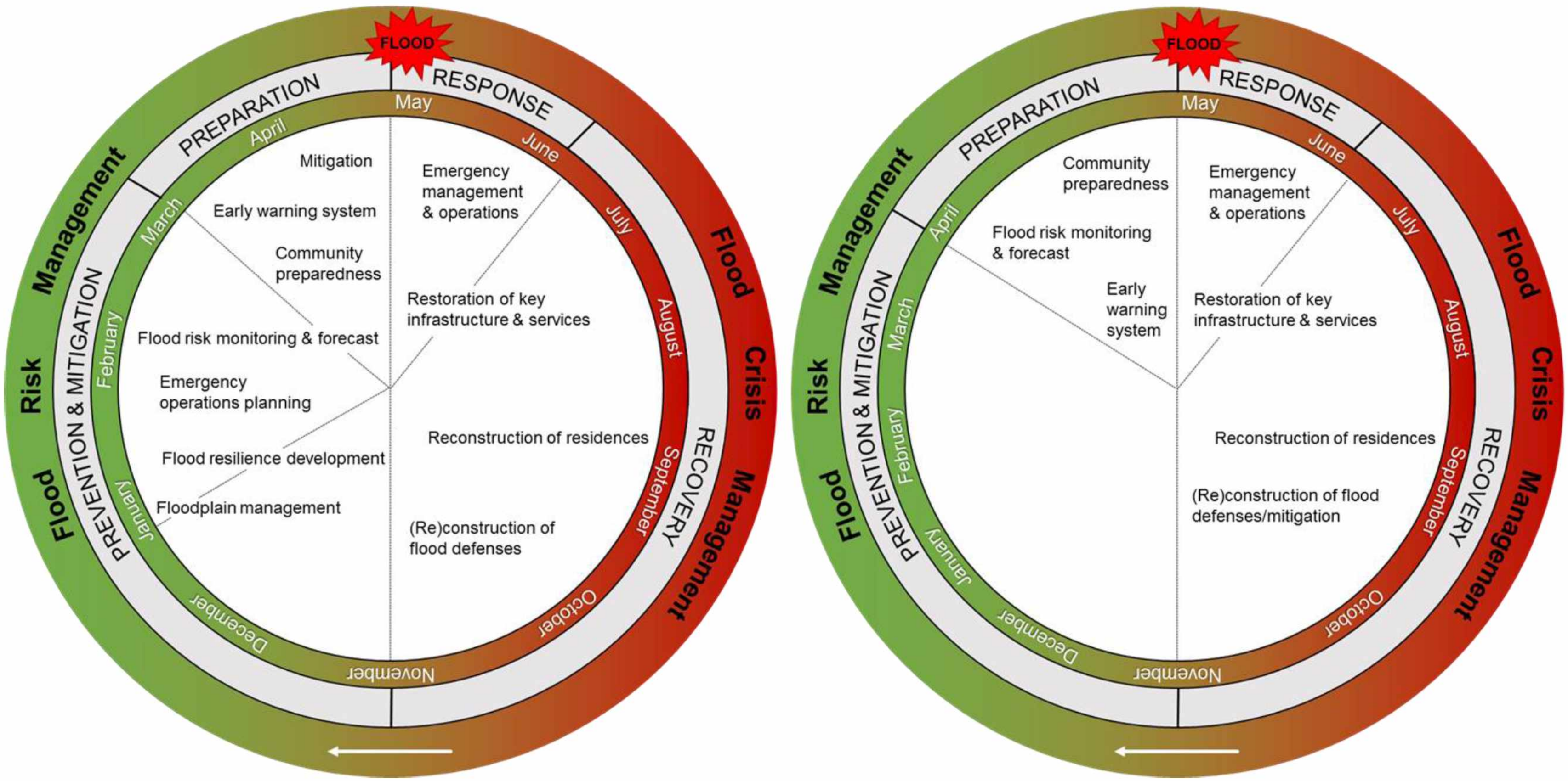

Figure 5. 7 Spring Flood Management Cycle Models. (left) Examples of interagency activities during key flood risk and crisis management phases in the Sakha Republic; (right) Examples of activities during key flood risk and crisis management phases in Alaska. Modified from Kontar et al., in press.

Approximately *four months prior to the breakup onset* (Figure 5.7), an interagency working group forms to allocate the necessary resources for flood prevention, mitigation, preparedness, and potential relief and recovery efforts, and to assign tasks and responsibilities among stakeholders involved in flood risk and crisis management (Androsov, 2015). The group consists of representatives from federal, republic, and regional emergency preparedness and relief agencies and local governments. The group's decision-making is based on the breakup and flood forecasts from Roshydromet (Androsov, 2015; Kusatov, 2015).

Around *two months prior to the breakup onset* (Figure 5.7), the working group begins to collaborate on detailed flood risk and crisis reduction strategies (Androsov, 2015). The working group identifies communities at risk, and determines appropriate short-term (mechanical) ice jam mitigation measures (Table 5.1), based on the up-to-date breakup forecast from Roshydromet. At this stage, LBWM issues flood watch for communities that Roshydromet identified at risk. Representatives from LBWM, MChS, and FRRRA initiate collaborations with local administrations about flood preparedness, prevention, and potential flood relief and recovery efforts (Androsov, 2015; Bykov, 2015; Platonov, 2015; Yadreev, 2016).

Approximately *four-to-two weeks prior to the (potential) flood onset* (based on the breakup progression and regional weather conditions), state emergency management specialists conduct mechanical ice jam and flood mitigation efforts, including river ice weakening (i.e., ice cutting and dusting), and detonation (Table 5.1) (Androsov, 2015; Bykov, 2015; Platonov, 2015). Meanwhile, local administrations initiate community preparedness by establishing emergency response posts, and informing the population at risk about potential floods and mandatory evacuation (Yadreev, 2016). Evacuation of special groups at risk (e.g., elders, children, and disabled residents), as well as relocation of cattle, cars, and farm equipment, begins two-to-three days prior to the potential flood (Yadreev, 2015).

After the floodwaters recede, an interagency commission evaluates the damages and determines individual (family) and public compensation (Androsov, 2015; Gavrilyeva et al., in press; Kontar et al., in press). As soon as the damage assessments are completed (usually by late June or early July), the rebuilding of houses as well as critical infrastructure and services begins (Gavrilyeva, et al., in press). The duration of flood recovery depends on the remoteness and isolation of the impacted communities, and the extent of damage.

Edeytsy's road accessibility and proximity to the Republic's capital and largest urban center, Yakutsk, facilitates prompt flood relief and recovery. Recent recovery efforts were also expedited by the extensive involvement of Edeytsy residents in the rebuilding process. After the 2013 flood, Edeytsy residents provided the necessary work force to rebuild the kindergarten, school, and community center buildings by October 2013 (Yadreev, 2015).

The described above unified and centralized flood management system facilitates the availability of the necessary financial and human resources to execute flood prevention and relief efforts in a timely and effective manner (Figure 5.8) (Kontar & Trainor, 2016; Kontar et al., 2016; Gavrilyeva et al., in press). However, in this scenario the Russian and Sakha state governments administrate flood management programs via top-down regulations at the detriment of local actions (Gaillard & Mercer, 2012; Kontar et al., in press). Local governments do not take part in flood management planning, but are merely tasked to relay actions from the top down. Opinions and knowledge of the population at risk are not encouraged or incorporated in the decision-making (Kontar et al., in press).

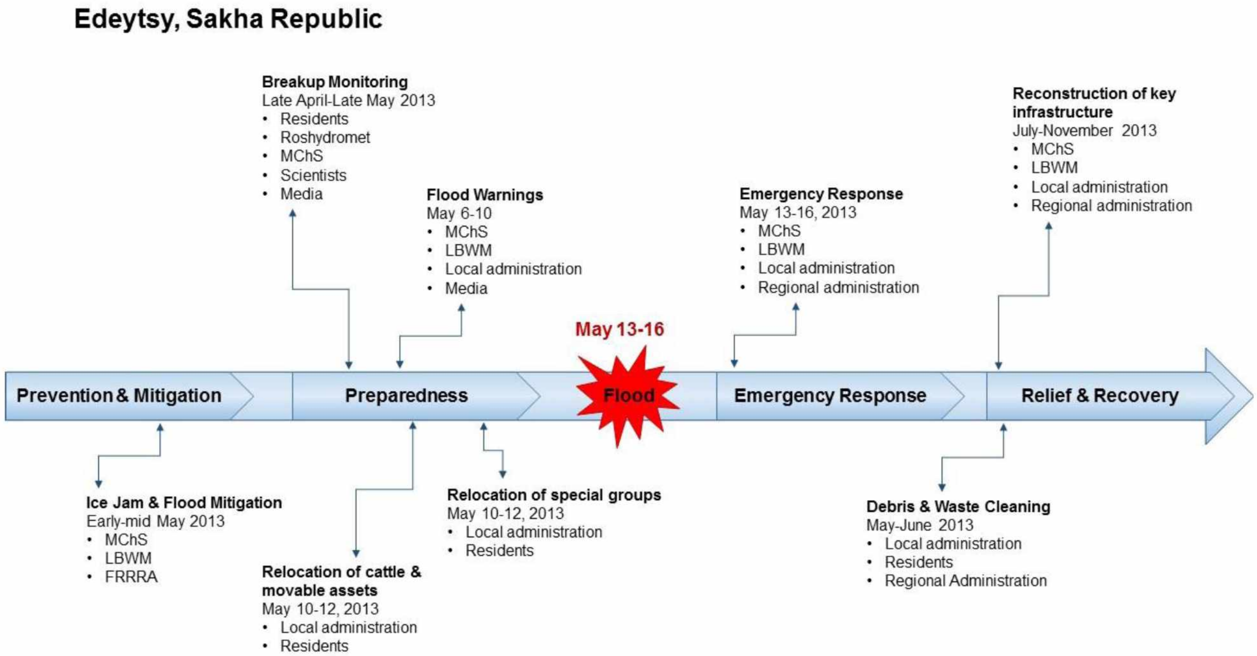

Figure 5. 8 Timeline of Flood Management in Edeytsy. The timeline depicts significant efforts during the flood prevention, mitigation, and preparedness phases. Proactive flood management resulted in timely and effective flood relief and recovery.

In the Sakha Republic, flood management is executed predominantly by MChS agents, which rely on military chain of commands and top-down regulations (Platonov, 2015). Since the underlying political, economic, social, and cultural causes of spring floods are not regarded as civil-defense matters, they remain largely ignored (Gaillard & Mercer, 2012; Kontar et al., in press). After flood recovery is completed, the community's vulnerability still remains. Continuing not to include local stakeholders into the decision-making process would further propagate the implementation of flood management strategies that do not help to reduce the communities' vulnerability and risk drivers (Kontar et al., in press).

In Alaska, the breakup flood cycle begins with flood response efforts (Figure 5.7). No centralized flood risk reduction efforts are conducted prior to the breakup onset. Once a flood overwhelms a community's capacity, local administration requests the state's support. If the flood exceeds the state's resources, the governor requests a federal disaster declaration and support (McEntire, 2007; Denver, 2016). As pointed out by Kontar et al. (2015) and Taylor et al. (2016), this succession significantly delayed relief and recovery efforts in Alaska in 2013.

A series of breakup floods ravaged Galena and four other communities in Interior Alaska from May 17 through June 11, 2013 (Plumb, 2015). Governor Parnell requested a major disaster declaration on May 30 (DHS, 2014). On June 25, President Obama issued a Major Disaster Declaration for Alaska and authorized FEMA to provide the necessary individual and public assistance (DHS, 2014; FEMA, 2016b). Reconstruction of infrastructure and homes did not begin until August, and was completed two years later (Figure 5.9) (Kontar et al., 2015; Korta, 2016).

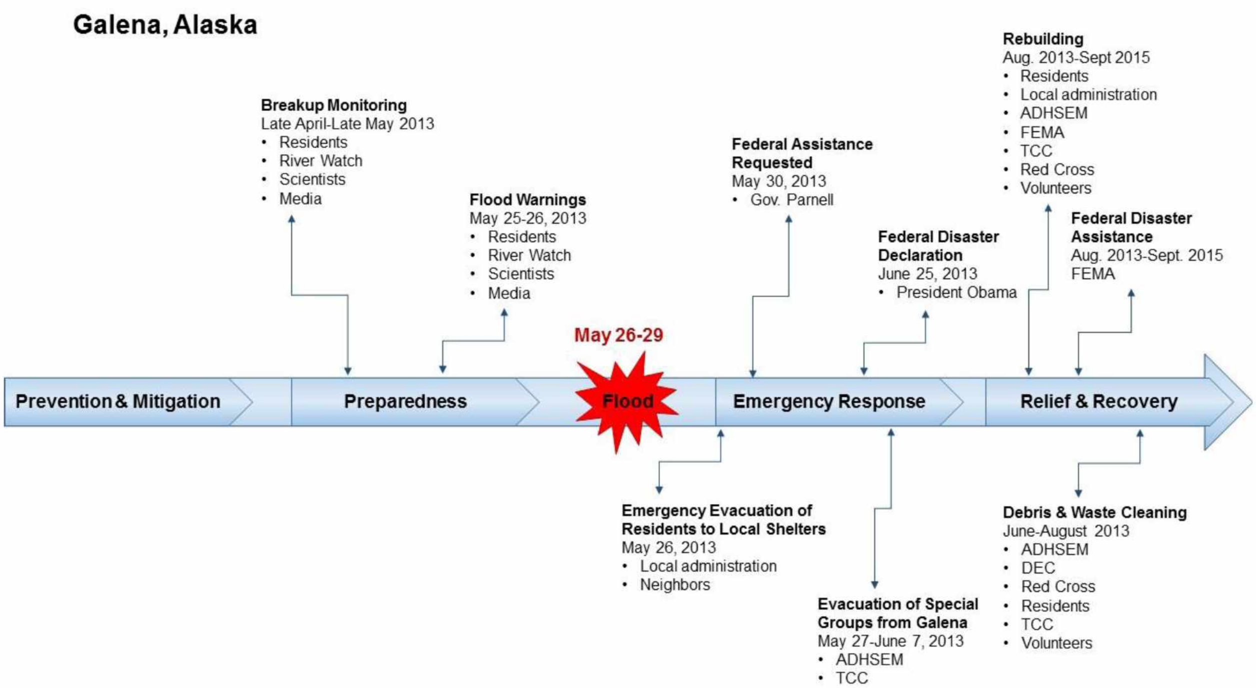

Figure 5. 9 Timeline of Flood Management in Galena. The timeline depicts a lack of preventative and preparedness measures, which led to severe adverse impacts and delays in flood relief and recovery efforts.

As summarized by Kontar et al. (2015), the delays in flood relief and recovery were caused by Galena's remoteness, Alaska's limited infrastructure, short rebuilding season due to the early winter onset, and a lack of interagency communication and collaborations. According to Pelkola and Korta (2015), Denver (2016), and Korta (2016) most of the valuable response time after the 2013 flood was spent on a range of paperwork and approvals. Upon their arrival at a disaster site, FEMA agents first conduct an additional damage assessment to verify the warranty of a federal disaster declaration (Robert T. Stafford Disaster Relief and Emergency Assistance Act [Stafford Act], 2013; DHS, 2014). An additional assessment can postpone the recovery efforts up to few a weeks.

FEMA also experienced delays in implementing changes to its Other Needs Assistance (ONA) policy for Alaska (DHS, 2014; Pelkola & Korta, 2015; Kontar et al., 2015). ONA provides financial assistance to the uninsured or under-insured disaster survivors who do not have other means to replace household and essential personal property items (Stafford Act, 2013). In the case of Galena, the aforementioned items included hunting and fishing gear (e.g., boats, motors, guns, and freezers) (DHS, 2014). As previously discussed, Galena's population largely depends on subsistence hunting and fishing. Galena residents lost their fish and game stocks plus their subsistence gear in the flood; thus residents needed ONA funds to feed their families and prepare for the winter (Pelkola & Korta, 2015; Kontar et al., 2015).

The survey responses indicate the frustration of Galena residents with FEMA personnel (Figure 4.7) (Kontar et al., in press). Galena residents and administration expressed concern that out of state emergency managers had limited experience tailoring disaster assistance to the needs of remote, rural Alaskan communities with limited cash. Federal responders are usually trained in lower latitudes, and thus are unfamiliar with the geographic area as well as the unique logistical and cultural features of Alaska (Kravitz & Gastaldo, 2013; Benoit, L., 2014). It is especially apparent and frustrating to the flood survivors in remote communities such as Galena, when FEMA agents ask them to "drive down to Anchorage to sign forms" (Andrews, 2013 as cited in Kontar et al., 2015). This and other mishaps could have been avoided if FEMA had collaborated with the TCC officials, who offered to serve as intermediaries between the agency and local tribal members (DHS, 2014; K. Wright, personal communication, March 14, 2016).

Flood relief in Galena and other impacted rural communities could have been faster if federal and state agencies used aircraft as well as barges to bring supplies into Galena (DHS, 2014; FEMA, 2016b). While barges are more cost-effective, they are also much slower. Moreover, barging companies have a limited number of vessels. The disaster supplies took space ordinarily used for transporting other items to be sold in rural communities. In turn, local merchants suffered severe financial consequences; a few went bankrupt (DHS, 2014). Most families from Interior Alaska overstock food and housekeeping supplies in Fairbanks and barge the goods to their communities before the freeze-up. Unable to barge their supplies, most residents had to fly them in, and thus suffered additional financial losses (DHS, 2014; Korta, 2016).

To facilitate timely and effective disaster response in rural Alaskan communities such as Galena, federal and state agencies could adapt their policies and strategies to the unique needs of impacted populations who have limited cash resources and who reside in remote and inaccessible locations (Kontar et al., in press). These strategies need to be in place before a disaster strikes. To have a clear understanding of the communities at risk, local stakeholders as well as their knowledge, opinions, and concerns should be integrated into the decision-making process (Kontar et al., in press).

As pointed out by Kontar et al. (2015), the River Watch is the most prominent example of effective interagency communication and collaboration in Alaska. For over 50 years, River Watch has been conducting assessment of ice conditions throughout Alaska with the goal to provide accurate assessments of flood threats and navigational hazards (National Weather Service [NWS], n.d.; Plumb, 2015). To conduct these assessments, the River Watch engages (on a volunteer basis) private and commercial pilots as well as village residents to provide their observations on the ice conditions, and thus supplement reports acquired from ground observations, aerial reconnaissance, and remote sensing (Kontar et al., 2015).

The River Watch is managed by NWS and supported by the ADHSEM (NWS, n.d.). During the River Watch, NWS hydrologists are tasked to conduct flyovers with the ADHSEM personnel. Scientific experts determine whether ice and river conditions are likely to cause ice jams and flooding by identifying potential locations of ice jams, flood threat, and magnitude of flooding (Kontar et al., 2015; Plumb, 2015). They also monitor water conditions if flooding is occurring, and forecast when floodwaters will recede (NWS, n.d.; Plumb, 2015). This information is crucial for the ADHSEM in determining best approaches in assisting endangered communities with emergency preparedness, evacuation, and/or response (Denver, 2016; Kontar et al., 2015).

The River Watch team also works closely with local emergency management, the community, and tribal officials by providing regular briefings on the current river, ice, or flooding conditions (Kontar et al., 2015). They often take community leaders on flyovers to get a local perspective and knowledge of the situation. For example, during the flood in Galena in May 2013, an ADHSEM official was on the ground assisting the community while a NWS hydrologist continued to make frequent flights over the ice jam and flooded area to determine if conditions would improve or get worse (Kontar et al., 2015). A NWS hydrologist would also conduct regular briefings to the emergency officials and community leaders on the ground.

In rural Alaska, the Alaska River Watch program has been fostering a long-term dialogue with the local emergency management, tribal officials, and residents of rural Alaska communities (Kontar et al., 2015; Plumb, 2015). As a result, they were able to establish and maintain a sense of partnership as well as trustful and reliable communication patterns between multiple disaster actors (Kontar et al., 2015). Due to their efforts in developing long-lasting, open, and reciprocal communication with the community, the River Watch program is able to provide information and guidance to local officials and residents so they can take prompt actions (Kontar et al., 2015). In addition to establishing and fostering effective communication with emergency state agents and affected communities, the Alaska River Watch program provides flood forecasting and warnings as necessary precautionary measures.

River Watch is an example of effective disaster communication practice. To advance the overall flood risk reduction in Alaska, other key stakeholders, including FEMA, Red Cross, TCC as well as representatives from regional and local administration should join the dialogue, and thus facilitate cooperation and mutual learning (Kontar et al., in press). The dialogue approach to flood risk communication is challenging as it involves 'cross-cultural' communication between outside actors (disaster managers) and inside actors (community members) (Figure 2.8) (Brenner, 2001; Neumann, 2009; Gaillard & Mercer, 2012). Review of academic literature and practitioners' reports has revealed three communication approaches that could facilitate the interagency collaboration during the flood cycle (Figure 2.7) in Alaska.

Culture and ethnicity approach, convergence communication approach, and social network contagion approach focus on the two-way communication that takes into account cultural, ethnic, and socioeconomic features of all stakeholders affected by the disaster (Table 2.5) (Lundgren & McMakin, 2009 as cited in Kontar et al., 2015). Specifically, *the culture and* *ethnicity approach* centers on the cultural norms, as well as education level and language proficiency, in addition to household structure influence whether population at risk receives information, how they interpret it and their subsequent response actions and time (Kontar et al., 2015).

The convergence communication approach is based on the fact that communication should be a long-term process, in which values of the risk-managing organizations and their audiences carry equal importance (Rogers & Kincaid, 1981; Höppner et al., 2010 as cited in Kontar et al., 2015). In this way, communication might help to anticipate and mediate potential conflict between different actors during disaster response (Kontar et al., 2015).

Proponents of *the social network contagion approach* suggest that effective disaster communication is conducted through the social networks of communities (Höppner et al., 2010 as cited in Kontar et al., 2015). In other words, rather than targeting individuals, risk-managing agents should team up with the key social leaders of the affected communities. The underlying assumption of this approach is that people rely more on opinions from people that influence their lives on a regular basis. Therefore, by creating a liaison with community leaders, risk-managing agents would be able to establish trust with other members of the group (Kontar et al., 2015).

Although the aforementioned communication approaches might be effective in advancing flood risk reduction in Galena, they would not be effective for all hazards and any stakeholder configuration (Kontar et al., in press). To be effective, risk communication methods foremost must match the type of risk, and the stakeholders' perception of risk (Slovic et al., 1979; Fischhoff, 1995; Covello & Sandman, 2001). As pointed out by Slovic (1987), those who are exposed to risks and those who are responsible for managing risks view risks differently. Disaster managers and physical scientists evaluate risks strictly in terms of quantitative assessments of mortality and destruction; while most people's perception of risk is more complex as it involves an array of psychological and cognitive processes (Slovic, 1987). Thus, it is important to incorporate in risk assessments the role of emotions and cognition in the conception of danger among the population at risk.

The analysis of the case studies demonstrated that interagency communication and collaboration play a crucial role in the effectiveness of flood risk reduction (Kontar et al., in press). A clear communication plan should be a central component of any flood risk reduction program (Gaillard & Mercer, 2012; Sendai Framework, 2015). Reducing flood risk also requires accurate identification, assessment, and reduction of its driving forces (UNISDR, 2015). As illustrated via the case studies, flood risk results from the complex interactions between a series of natural processes and human actions that generate conditions of spring floods (i.e., hazard), and communities' exposure and vulnerability (UNISDR, 2015; Kontar et al., in press).

Underlying flood risk drivers differ in every community, and so should flood risk reduction approaches (Kontar et al., in press). To construct an appropriate flood risk reduction framework it is important to foremost conduct an integrated assessment of flood risk based on local and scientific knowledge, followed by establishing a dialogue among the diverse stakeholders on issues and potential solutions, and finally arriving at a range of top-down and bottom-up initiatives and in conjunction selecting the appropriate strategies.

6. Key Findings, Implications, and Conclusions

Throughout this dissertation, I have identified and assessed three primary components of flood risk – hazard, exposure, and vulnerability – in rural riverine communities in Alaska, United States and the Sakha Republic, Russia. I have also compared the existing frameworks in flood risk reduction in both regions, and outlined best practices. Chapter One introduced my research interests, key objectives, and questions. In Chapter Two, I reviewed academic literature and practitioners' reports in the fields of disaster risk reduction and management, flood risk, risk communication, and disaster resilience in rural communities. Chapter Three detailed my case study methods and analysis. In Chapter Four, I explored underlying flood risk drivers in rural riverine communities in Alaska and the Sakha Republic via the Pressure and Release (PAR) model. In Chapter Five, I compared the existing flood risk reduction frameworks in Alaska and the Sakha Republic via the disaster cycle model. This concluding chapter presents a brief summary of the study and key findings, which are followed by a brief discussion of the study's implications, limitations, and suggestions for future research.

6.1 Summary of the Study

With the main goal to identify best practices in spring flood risk reduction, I conducted a comparative analysis between two flood-prone communities in Alaska, United States and the Sakha Republic (Northeast Siberia), Russia (Figure 1.1). Comparative parameters included natural and human causes of spring floods, effectiveness of spring flood mitigation and preparedness strategies, and the role of interagency communication and cooperation in flood risk reduction (Table 1.1). Implementing the PAR model to both case studies, I identified the underlying drivers of spring flood risk and their historic interrelations in both communities. I also implemented the disaster cycle model to trace the existing practices of flood risk management in Alaska and the Sakha Republic.

For the case study analysis, I selected two flood-prone rural communities, Galena in Alaska, United States and Edeytsy in the Sakha Republic, Russia. Within a week of each other in May 2013, Galena and Edeytsy sustained major ice jam floods (Figure1.2). In both communities, the floodwaters and ice floes destroyed or severely damaged nearly all homes and key infrastructure and displaced hundreds of people (Kontar et al., 2015; Taylor et al., 2016; Gavrilyeva, in press). With several residences remaining under construction, the memories of the floods are still alive in both communities. Galena and Edeytsy residents were interested in the research project, and eager to share their experiences with each other with the goal to identify best practices in recovering from past floods and minimizing future risks.

To conduct the necessary data collection on site, a bilateral and interdisciplinary team was established as part of the US Department of State U.S.-Russia Peer-to-Peer Dialogue Initiative. The team consisted of US and Russian geoscientists, social scientists, students, emergency managers, and civil and tribal community leaders. Each of the team participants represented a key stakeholder group that takes part in flood management in both countries, and shared his/her expertise with the relevant counterparts. A detailed description of the Peer-to-Peer project is attached in Appendix D. This project was unique; there is little record in the academic literature and practitioners' reports of truly multi-stakeholder projects that involved simultaneous collaborations in disaster risk reduction among local communities, scientists, and regional and national governments.

Throughout the project I systematically collected, analyzed, and synthesized the data, and outlined emerging concepts and patterns in spring flood risk reduction in Alaska and the Sakha

Republic. I acquired the data through a combination of qualitative methods. In addition to direct observations and secondary data review, I conducted focus groups with the representatives from agencies and institutions responsible for flood management in both regions, and surveys with the population impacted by the floods in May 2013. The main goal of focus groups in Alaska and the Sakha Republic was to identify the existing practices in spring flood risk reduction, as well as the key challenges stakeholders face during flood risk and crisis management phases in both regions. The main goal of the surveys was to assess opinions, perceptions, and attitudes in both research sites regarding the effectiveness of the flood risk and crisis management efforts (Table 1.2).

I conducted focus groups and surveys during the site visits to Edeytsy in November 2015 and Galena in March 2016. Site visits also provided great opportunities for direct observations of flood destruction, recovery efforts, and community dynamics in both research sites. To fill in the data gaps, I conducted secondary data analysis, which consisted primarily of the archival review of hydrological and climatological reports, news stories, feature stories, and government reports that depicted causes and impacts of spring floods dating back to the early twentieth century in Alaska and the Sakha Republic. Archival review also included memoires and other personal reflections of Galena and Edeytsy residents on the historical floods. Collecting data from multiple sources allowed me to triangulate the evidence.

6.2 Key Findings

This comparative case study has resulted in several important findings and lessons, which if accepted and implemented by disaster practitioners and policy makers will help reduce adverse impacts of spring floods in rural northern communities. Foremost, historical analysis revealed that the vulnerability of northern rural communities to spring floods traces back to the original settlements of Native Alaskans and Sakha into their permanent locations.

Traditionally, Native communities in Alaska and the Sakha Republic avoided spring floods by not establishing permanent settlements in floodplains. Seasonally nomadic, Native Alaskans migrated between their fishing and hunting camps (Arundale, 1985; Sprott, 2000). Native Sakha originally settled around lakes located on higher ground (Lindenau, 1983; Vakhtin, 1992). Compelled by government programs to settle on floodplains in more permanent structures and communities in the first half of the twentieth century, Native Alaskans and Sakha began to face flood risk (Kontar et al., 2016). Flood risk was not factored into investment decisions during the initial settlement decisions (Kontar et al., in press). Communities were settled on the shores of the Lena and Yukon Rivers with no structural or nonstructural protection against spring flooding. The economic and political incentives (e.g. establishment and maintenance of the USAF base in Galena and kolkhoz in Edeytsy) for the communities' expansion further outweighed considerations for flooding.

Although pursuing different underlying goals, state governments in Alaska and the Sakha Republic similarly focused on rapid community settlement and expansion. The growing concentration of people, infrastructure, livelihoods, and services close to the riverbanks has been driving flood exposure in Galena and Edeytsy for the last eight decades (Gavrilyeva, in press; Kontar et al., in press). The original absence of flood risk governance resulted in a lack of building codes, and flood prevention, mitigation, and preparedness measures. For decades, flood-ravaged houses in Galena and Edeytsy were rebuilt on the same places with no intent to reduce populations' exposure and vulnerability to spring floods (Morgan, L., 1972; Lindenau, 1983; Pelkola & Korta, 2015; Yadreev, 2016).

As Galena and Edeytsy became more strategically important by the mid-1940s, state governments began to implement flood management strategies to protect valuable assets from the adverse impacts of spring floods. Unlike most disasters, opportunities for reducing spring flood risk lie not only in reducing vulnerability and exposure of the at-risk population, but also in reducing the severity of the hazard itself (Kontar et al., in press). Spring floods may be prevented from occurring through appropriate ice jam mitigation efforts. Through the analysis of focus group discussions with US and Russian representatives from the agencies responsible for flood risk management, this research reveals two key categories of ice jam flood prevention and mitigation strategies in Alaska and Sakha (Table 5.1):

1. *Ice jam prevention*: preventive measures to eliminate or lessen the likelihood of a damaging ice jam event from occurring (e.g., river ice dusting, cutting, and detonation). These short-term, mechanical mitigation measures are implemented to weaken or breach ice jams that have already formed (Figure 5.2).
2. *Reduction of ice jam flood impact*: preventive measures undertaken to reduce the potential damages from floodwater and ice debris. These measures are further divided into structural (e.g., construction of dikes and elevation of houses on steel pilings) and nonstructural (e.g., floodplain management and population relocation) (Figure 5.3). These long-term flood risk mitigation efforts are usually initiated right after the floods. The implementation of these measures usually requires large upfront investments and might take several years.

A range of mechanical ice jam mitigation efforts, such as ice cutting, weakening, and demolishing had been implemented in Alaska from the mid-1940s until late 1980s, and are still largely implemented in the Sakha Republic. Reported satisfaction levels indicate a higher satisfaction rating with mitigation and prevention measures among Edeytsy residents. Galena residents expressed disappointment regarding the absence of mechanical ice-jam mitigation efforts in Alaska. Watching their communities ravaged by ice floes, people hoped for more proactive flood mitigation efforts.

Mechanical ice jam mitigation efforts are more proactive, but not necessarily effective. These techniques are designed according to hydrological models developed by academic and state scientists; however, no criteria for the effectiveness of these models has yet been established (Buzin et al., 2014; Tananaev, 2016). There is no published evidence of these methods' effectiveness, only anecdotal. Advances in ice jam and flood risk mitigation would improve the overall flood risk reduction in both regions (Kontar & Trainor, 2016). Further in-depth comparative analysis is needed to determine the costs and benefits of spring flood mitigation and prevention measures.

Structural spring flood mitigation efforts were implemented in both communities before and after the floods in May 2013 (Kontar et al., in press). A dike, constructed in Galena in 1944, is protecting the airport (Figure 4.5). During the 2013 flood, the former USAF base was the only part in town that remained dry. A construction of a dike in Edeytsy was initiated after the flood in May 2010. Due to the incremental funding, the construction is ongoing six years later (Figure 4.4). Edeytsy administration and residents have high hopes for the dike to protect their houses, as well as farm and pasture lands from spring floods (Yadreev, 2016; Kontar et al., in press).

After the flood in May 2013, most houses in Galena were elevated on steel pilings at least one foot above the highest flood level (Figure 5.3) (Denver, 2016; Korta, 2016). Although their unaesthetic appearance and inconvenience for the elders, Galena residents believe that their houses and their property inside houses are protected from the spring floods (Pelkola & Korta, 2015; Kontar et al., in press). However, their movable assets, such as cars and snowmobiles, remain exposed to floods.

Partial relocation of the population has also been implemented in both communities to reduce flood risk. A large portion of Galena residents relocated to a new site after a major flood in May 1971 (Morgan, L., 1972). Opinions of the local population regarding relocation were not accounted for when choosing the new site's location (Kontar et al., in press). For the construction of Galena's New Town, the Alaska State Housing Authority (ASHA) allocated a site near Alexander Lake approximately one mile away from Old Town. ASHA surveyed the proposed relocation site and determined that it was appropriate for relocation as "it has received very little water during this record high flood" (News Miner, 1971b). Galena residents thought the proposed site was too low, and wanted to move the village onto high ground on the USAF dumpsite, Campion (News Miner, 1971b). Unable to receive federal approval, New Town was settled near Alexander Lake. Over 90 percent of New Town's buildings were destroyed or severely damaged by the 2013 flood (Kontar et al., 2015). The Campion site remained dry during all flood years, including 2013 (Denver, 2016; Korta, 2016).

After the 2013 floods, a series of new long-term spring flood mitigation efforts were launched in Galena and Edeytsy. Their effectiveness will be determined during the next flood. Despite mitigation measures, in most cases, some people and property remain vulnerable to floods. Thus, flood preparedness is an integral part of flood risk reduction. During the 2013 floods, preparedness measures in Galena and Edeytsy included early warning, evacuation of at-risk population and livestock to higher ground, and facilitation of rapid response.

A large portion of Galena's population (i.e. New Town residents) had not experienced a major ice-jam flood in their lifetime, and thus developed a false sense of security (Pelkola & Korta, 2015). Caught off guard by the severity of the 2013 flood, most Galena residents did not take precautionary measures to protect their houses, movable assets, and animals (Figure 5.6)

(Korta, 2016). Despite the time constraints, the evacuation measures were successful and resulted in no fatalities (Kontar et al., 2015).

Experienced with more frequent severe flooding, Edeytsy residents were more proactive in relocating their cattle, farm equipment, and personal vehicles to higher ground (Kontar et al., 2016). In Edeytsy and other rural Sakha communities, annual flood preparedness measures begin with the evacuation of special risk groups approximately two-three days prior to the potential flood (Androsov, 2015; Yadreev, 2015). In the Sakha Republic, the overall coordination of breakup flood mitigation, preparedness, response, and recovery efforts are organized and initiated at the federal level. This unified and centralized system encourages an ongoing year-round interagency communication throughout the flood cycle (Figure 5.7). It also facilitates the availability of the necessary financial and human resources to execute flood prevention and relief efforts in a timely and effective manner (Kontar & Trainor, 2016; Kontar et al., 2016).

However, in this scenario the Russian and Sakha state governments administrate flood management programs via top-down regulations at the detriment of local actions (Gaillard & Mercer, 2012; Kontar et al., in press). Local governments do not take part in flood management planning, but are merely tasked to relay actions from the top down. Opinions and knowledge of the population at risk have not been encouraged or incorporated in the decision-making regarding spring flood management (Kontar et al., in press).

In the Sakha Republic, flood management is executed predominantly by MChS agents, which rely on military chain of commands and top-down regulations (Table 1.3) (Platonov, 2015). Since the underlying political, economic, social, and cultural causes of spring floods are not regarded as civil-defense matters, they remain largely ignored (Gaillard & Mercer, 2012; Kontar et al., in press). After flood recovery is completed, the community's vulnerability still remains. Continuing not to include local stakeholders into the decision-making process would further propagate the implementation of flood management strategies that do not help to reduce the communities' vulnerability and risk drivers (Kontar et al., in press).

To facilitate the integration of local stakeholders and knowledge in flood risk reduction, disaster scholars call for decentralization (Gaillard & Mercer, 2012; O'Brien et al., 2012; Sendai Framework, 2015). Decentralization could strengthen capacities of local administration in rural Sakha to mitigate, prepare, respond to, and recover from spring floods. On the other hand, local rural governments, such as in Edeytsy would lack financial means and skills to undertake substantial flood risk management efforts, such as building dikes or relocating at-risk population, independently from the central Russian government (S. Yadreev, personal communication, February 10, 2017). In this scenario, decentralization would undermine flood risk reduction.

In Alaska, the breakup flood cycle begins with flood response efforts (Figure 5.7). No centralized flood risk reduction efforts are conducted prior to the breakup onset. Once a flood overwhelms a community's capacity, local administration requests the state's support (Denver, 2016). If the flood exceeds the state's resources, the governor requests a federal disaster declaration and support (McEntire, 2007; Denver, 2016). As pointed out by Kontar et al. (2015) and Taylor et al. (2016), this succession significantly delayed relief and recovery efforts in Alaska in 2013. The lack of interagency communication resulted in additional damage assessments and approvals, and adjustments of paperwork and regulations (Kontar et al., 2015; Pelkola & Korta, 2015).

The survey responses indicate the frustration of Galena residents with FEMA personnel. Galena residents and administration expressed concern that out of state emergency managers had limited experience tailoring disaster assistance to the needs of remote, rural Alaskan communities with limited cash (DHS, 2014; Pelkola & Korta, 2015). To facilitate timely and effective flood response in rural Alaskan communities such as Galena, federal and state agencies could adapt their policies and strategies to the unique needs of impacted populations who have limited cash resources and who reside in remote and inaccessible locations (DHS, 2014). These strategies need to be in place before a disaster strikes. To have a clear understanding of the communities at risk, local stakeholders as well as their knowledge, opinions, and concerns should be integrated into decision-making (Gaillard & Mercer, 2012).

To advance the overall flood risk reduction in Alaska, all stakeholders, including ADHSEM, FEMA, Red Cross, TCC as well as representatives from regional and local administration should join the dialogue, and thus facilitate cooperation and mutual learning (Kontar et al., 2016). The dialogue approach to flood risk communication is challenging as it involves 'cross-cultural' communication between outside actors (disaster managers) and inside actors (community members) (Brenner, 2001; Neumann, 2009; Gaillard & Mercer, 2012).

Review of academic literature and practitioners' reports has revealed three communication approaches that could facilitate the interagency collaboration during the flood cycle in Alaska: the culture and ethnicity approach, the convergence communication approach, and the social network contagion approach (Kontar et al., in press). As summarized by Kontar et al. (2015), these approaches focus on two-way communication that takes into account cultural, ethnic, and socioeconomic features of all stakeholders impacted by the flood. Specifically, the culture and ethnicity approach centers on the cultural norms, as well as education level and language proficiency, in addition to household structure influence whether population at risk receives information, how they interpret it and their subsequent response actions and time (Kontar et al., 2015).

The convergence communication approach is based on the fact that communication should be a long-term process, in which values of the risk-managing organizations and their audiences carry equal importance (Höppner et al., 2010 as cited in Kontar et al., 2015). In this way, communication might help to anticipate and mediate potential conflict between different actors during disaster response. Proponents of the social network contagion approach suggest that effective disaster communication is conducted through the social networks of communities (Höppner et al., 2010 as cited in Kontar et al., 2015). Rather than targeting individuals, risk-managing agents should team up with the key social leaders of the affected communities because people rely more on opinions from individuals that influence their lives on a regular basis (Kontar et al., 2015). Therefore, by creating a liaison with community leaders, risk-managing agents would be able to establish trust with other members of the group (Kontar et al., 2015).

Although the three aforementioned communication approaches might be effective in advancing collaboration between stakeholders and flood risk reduction in Galena, they would not necessarily be effective for all hazards and any stakeholder configuration. To be effective, risk communication methods foremost must match the type of risk, and the stakeholders' perception of risk (Slovic et al., 1979). Thus, a clear communication plan should be a central component of any flood risk reduction program (Gaillard & Mercer, 2012; Sendai Framework, 2015).

Reducing flood risk also requires accurate identification, assessment, and reduction of its driving forces (Wisner et al., 2004; UNISDR, 2015). As illustrated via the case studies, flood risk results from the complex interactions between a series of natural processes and human actions that generate conditions of spring floods (i.e., hazard), and communities' exposure and vulnerability (UNISDR, 2015; Kontar et al., in press). Underlying flood risk drivers differ in every community, and so should flood risk reduction approaches. To construct an appropriate flood risk reduction framework it is important to foremost conduct an integrated assessment of flood risk based on local and scientific knowledge, followed by establishing a dialogue among the diverse stakeholders on issues and potential solutions, and finally arriving at a range of top-down and bottom-up initiatives and in conjunction selecting the appropriate strategies (Gaillard & Mercer, 2012; Kontar et al., in press).

6.3 Limitations

As highlighted in Chapter Three: Methods, I took a number of steps to ensure accurate and informative data collection and analysis throughout the course of this dissertation. Specifically, the protocols for focus groups and surveys were reviewed by experienced researchers as well as community leaders of both case sites. Researchers and community leaders were members of the Peer-to-Peer project. Review of protocols helped to ensure that questions raised in surveys and focus groups were appropriately phrased, and facilitated informative responses consisted with the goals of the study.

Moreover, I and at least one more project participant, kept detailed notes during focus groups, which we compared after each discussion to double check their validity. I also collected supplementary materials (e.g., PowerPoint presentations and media files), which were presented by the focus group participants. The supplementary materials provided figures and statistics from governmental agencies, which I included in data analysis.

To further enhance research credibility, I triangulated the acquired data by comparing and contrasting the survey responses with focus group discussions. I also supplemented the data acquired via surveys and focus groups with the secondary literature review and direct observations on site. However, despite these extensive efforts, this dissertation, as all research projects, has a few limitations.

First, the case study methodology implies that the results may or may not be transferrable to other circumpolar communities. Some of the results are, indeed, unique to the local context, such as the specific key institutions, and the underlying flood risk drivers and their historic interrelation. Since most rural communities in Alaska and the Russian North share the same root causes and dynamic pressures that result in their exposure and vulnerability to spring floods, the broad conclusions of this research may apply to other rural northern communities in the US and Russian North. To make this research more applicable to other circumpolar nations, I would expand the sample size to include other northernmost countries.

Second, the surveys were limited to households rather than individuals. As a result, the analysis did not emphasize the gender and age aspects of vulnerability among the respondents. Future research should incorporate larger population samples to allow for extensive statistical analysis of individual vulnerability factors among the overall population exposed to spring floods.

Third, I was unable to formally interview representatives from institutions and agencies involved in flood risk reduction in the Sakha Republic due to governmental restrictions. Though I believe the data from focus groups provided a close representation of the function of agencies involved in flood risk reduction, future research should attempt to gather individual interviews from all key governmental agencies to perform more elaborate analysis of the interagency collaborations.

6.4 Implications and Applications

This study has a number of possible applications. Because the study integrates the research from multiple disciplines, community knowledge, and practitioners' expertise, its applicability and relevance may span to other natural and technological disasters in rural northern communities. The immediate value of this study will likely be to the intended audience of policy makers and disaster risk managers, who are seeking guidance as to how they might reduce or even eliminate disaster risk in rural northern communities through accurate assessment of the underlying risk factors. Leaders of at-risk communities might find this study useful as well, as it might help them identify appropriate practices in community preparedness and disaster relief. This study may also be valuable to disaster researchers, who are seeking an integrated framework with which to explore and/or assess the underlying factors of risks in rural northern communities.

This study further proves that interagency collaboration plays a crucial role in disaster risk reduction, and provides an overview and analysis of risk communication approaches that are effective in helping disaster practitioners establish and maintain interagency collaborations. It also includes guidelines for establishing and maintaining a dialogue between those who are facing the risk and those responsible for managing disaster risk.

Through the review of academic literature and professional reports in the fields of disaster risk reduction, and disaster risk in the North, I found three main trends:

1. Disaster risk reduction research has been predominantly focused on megacities and urban areas, thus underrepresenting the risk in rural communities (UNISDR, 2015; Birkmann et al., 2016; IFRC, 2016a).
2. Disaster risk in the North has been primarily concerned with coastal flooding and erosion (e.g., IRDR, 2014; NAS, 2016), and oil spills (e.g., Rossi, 2013; IRDR, 2014).
3. In most cases, disaster risk reduction in the North is coupled with climate change adaptation (e.g., Brunner et al., 2004; Ford & Smit, 2004; IPCC, 2012; Clement et al., 2013; Kelman et al., 2015). This long-term perspective is crucial for the sustainable

development of northern communities. However, it also neglects the immediate adverse impacts of disasters that are happening now.

This dissertation contributes to the existing research in the fields of disaster risk reduction and disaster risk in the North by expanding knowledge in the following areas: 1) disaster risk reduction in rural northern communities, 2) inland riverine flooding in the North, and 3) reduction of immediate disaster risks.

6.5 Conclusion and Recommendations

River ice thawing and breakup is an annual springtime phenomenon in the North. Depending on regional weather patterns and river morphology, breakups can result in floods (Beltaos, 2007). Breakup floods often cause catastrophic ice and water damage to exposed and vulnerable riverine communities, and lead to socioeconomic and ecological crisis (e.g., Gerard & Davar, 1995; Buzin, 2004; Pagneux et al., 2011; Kontar et al., 2015).

Spring flood risk is especially high in rural and remote communities, where flood relief and recovery are complicated by the region's unique geographical and climatological features, limited physical and communication infrastructure, and insufficient disaster mitigation and preparedness measures (Kravitz & Gastaldo, 2013; IRDR, 2014). To reduce flood risk, one needs to, foremost, accurately identify and assess it (Cutter et al., 2015; Sendai Framework, 2015). A risk, in the context of this research, is the likelihood of a spring flood occurring and resulting in loss, injuries, damage and destruction in rural northern communities (UNISDR, 2015; Kontar et al., in press).

Historical analysis revealed that spring flood risk in Galena and Edeytsy has resulted from complex interactions between a series of natural processes and human actions that generated conditions of hazard (i.e., spring floods), exposure, and vulnerability (Figure 2.1)

(GFDRR, 2014; Kontar et al., in press). Therefore, flood risk in Galena and Edeytsy can be reduced by managing conditions of ice-jam floods, and decreasing exposure and vulnerability of the at-risk populations (GFDRR, 2014; UNISDR, 2015; Kontar et al., in press).

Implementing the PAR model to analyze the vulnerability progression of Edeytsy and Galena has demonstrated that the vulnerability of both communities is deeply rooted in socio-economic and political processes (Kontar et al., in press). The progression of vulnerability in Galena and Edeytsy point to common root causes between the two research sites, including colonial heritage, unequal distribution of resources and power, top-down governance and limited inclusion of local communities into the decision-making process (Figure 4.10, Figure 4.11) (Kontar et al., in press). The communities of Galena and Edeytsy were settled in their permanent floodplain locations with no consideration of flood risk. Rapid expansion of both communities, along with miscommunication or lack of communication between stakeholders responsible for managing flood risks and those facing flood risks resulted in inadequate flood risk governance and management measures (Kontar et al., in press). Until the flood in May 2013, houses and infrastructure in Galena and Edeytsy were rebuilt in place after floods, thus exacerbating the communities' vulnerability. Reducing vulnerability is only possible through integration of local knowledge stakeholders in the decision-making processes regarding spring flood management.

Unlike most natural disasters, opportunities for reducing spring flood risk lie not only in reducing vulnerability drivers, but also in reducing the severity of the hazard itself (Kontar & Trainor, 2016; Kontar et al., in press). Throughout history, an array of ice jam prevention and mitigation measures have been implemented in the US and Russian North with varying degrees of success (Figure 5.1) (e.g., Belore et al., 1990; Buzin et al., 2014; Burrell et al., 2015). A series of mechanical ice jam mitigation and prevention techniques (e.g., ice dusting, blasting, and cutting) are implemented in the Russian North during every spring breakup. Although these measures are more proactive, there is no published evidence of these methods' effectiveness (Buzin et al., 2014; Tananaev, 2016; Kontar et al., in press). The selection of mitigation efforts should depend on the careful analysis of the causative factors of ice jams, and the unique features of the river channel and the floodplain (Buzin et al., 2014; Burrell et al., 2015). The decisions should be made collectively by representatives from at-risk communities and flood managing agencies, and should be based on coherent science-based assessments (Kontar et al., 2016). In practice, spring flood mitigation strategies are predominantly selected upon the availability of resources and time of flood managing agencies (Kontar et al., in press).

Spring floods are complex natural and social phenomena. Their scale, frequency, and impact can be effectively addressed only through holistic policy solutions (Boaz & Hayden, 2002; Cutter et al., 2015). Integrated flood risk reduction requires interdisciplinary research and interagency collaborations with a diverse group of stakeholders. Although increasingly regarded by both scholars and practitioners as a crucial step in reducing disaster risk, integrating knowledge, actions and stakeholders in disaster risk reduction remains challenging in policy and practice primarily due to the lack of trust between stakeholders (Brenner, 2001; Neumann, 2009; Gaillard & Mercer, 2012). To facilitate integrated spring flood risk reduction in the rural North, it is crucial to provide a space for a dialogue among key stakeholders, including communities facing flood risk.

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Appendix A
IRB Exemption Letter

UNIVERSITY OF ALASKA FAIRBANKS

(907) 474-7800
(907) 474-5444 fax
uaf-irb@alaska.edu
www.uaf.edu/irb

Institutional Review Board

909 N Koyukuk Dr. Suite 212, P.O. Box 757270, Fairbanks, Alaska 99775-7270

October 29, 2015

To:	John Eichelberger, PhD Principal Investigator
From:	University of Alaska Fairbanks IRB
Re:	[818885-2] Reducing Spring Flood Impacts for Wellbeing of Communities of the North

Thank you for submitting the Response/Follow-Up referenced below. The submission was handled by Exempt Review. The Office of Research Integrity has determined that the proposed research qualifies for exemption from the requirements of 45 CFR 46. This exemption does not waive the researchers' responsibility to adhere to basic ethical principles for the responsible conduct of research and discipline specific professional standards.

Title:	Reducing Spring Flood Impacts for Wellbeing of Communities of the North
Received:	October 28, 2015
Exemption Category:	2
Effective Date:	October 29, 2015

This action is included on the November 4, 2015 IRB Agenda.

Prior to making substantive changes to the scope of research, research tools, or personnel involved on the project, please contact the Office of Research Integrity to determine whether or not additional review is required. Additional review is not required for small editorial changes to improve the clarity or readability of the research tools or other documents.

- 1 -

Generated on IRBNet

Appendix B
Informed Consent Form

Reducing Spring Flood Impacts for Wellbeing of Communities of the North

IRB # 818885-1

Date Approved (TBD)

Description of the Study:

You are being asked to take part in a research study about the impacts of breakup floods on your community. One goal of this study is to learn how community prepares for breakup floods. Another goal is to learn how breakup floods could be better predicted in the future. And the final goal is to learn how disaster response and recovery can be improved. You are being asked to take part in this study because you lived in Galena during the flood in May 2013.

Please read this form carefully. We encourage you to ask questions and take the opportunity to discuss the study before making a decision on whether or not to participate. If you decide to take part, you will asked to participate in three one-hour long focus group discussions. You will also be asked to fill out questionnaires about your experience during the flood in May 2013.

Risks and Benefits of Being in the Study:

If you take part in this study, you will learn how people prepare for floods in other Arctic countries. You will also have an opportunity to learn about Russian Arctic culture and customs.

The risks to you if you take part in this study are possible unpleasant memories of the flood in May 2013. Please feel free to terminate your participation in this study at any time.

Confidentiality:
You may be sure that the information that you will share with us will be kept confidential. We will perform the following tasks to protect your confidentiality:

- Any information with your name attached will not be shared with anyone outside the research team.
- We will code your information with a number so no one can trace your answers to your name.
- We will properly dispose paperwork and securely store all research records.
- Your name will not be used in reports, presentations, and publications.

Your decision to take part in the study is voluntary. You are free to choose whether or not to take part in the study. If you decide to take part in the study you can stop at any time or change your mind and ask to be removed from the study.

Contacts and Questions:

If you have questions now, feel free to ask us now. If you have questions later, you may contact Katia Kontar at ykontar@alaska.edu or 907-474-1953, and/or John Eichelberger at jceichelberger@alaska.edu.

The UAF Institutional Review Board (IRB) is a group that examines research projects involving people. This review is done to protect the people like you involved the research. If you have questions or concerns about your rights as a research participant, you can contact the UAF Office of Research Integrity at 474-7800 (Fairbanks area) or 1-866-876-7800 (toll-free outside the Fairbanks area) or uaf-irb@alaska.edu.

Statement of Consent:

I understand the procedures described above. My questions have been answered to my satisfaction, and I agree to participate in this study. I am 18 years old or older. I have been provided a copy of this form.

____

Signature of Participant & Date

____

Signature of Person Obtaining Consent & Date

Survey Sample

1. How many times has your family experienced springtime floods in the past 20 years?___________________________

2. In what years did the floods take place? _______________

3. How many floods can you and your family remember during the last 50 years? Please indicate the number of floods and their years: ______________________________

4. 4. When was the last flood?____________________________

5. How many days did the floodwater stay in or on:

   - your house?____days

   - your yard?_____days

   - public infrastructure (e.g., roads, community center, school)?_____days

   - hunting grounds?____days

6. On a scale from 0-5, with 5 being the strongest, how would you rate the severity of the last flood?

   - flooded your yard_____points

   - flooded your first floor_____points

   - flooded your top floors_____points

   - the flood water rose to the roof_____points

   - flooded public infrastructure (e.g., roads, community center, school, clinic)_____points

7. What was the damage from the ice debris? Circle all that apply.

   - partial destruction to your house

   - damage to your outbuildings (e.g., greenhouse, shed, doghouses)

   - damage to the public infrastructure (e.g., power lines, roads)

8. Did you lose animals during the flood? If so, what kind and how many?_______________________________________

9. What was the damage to your:

   - car? (circle appropriate) had to be fixed OR could not be fixed

   - snowmachine? (circle appropriate) had to be fixed OR could not be fixed

   - boat? (circle appropriate) had to be fixed OR could not be fixed

10. What was the damage to your private property? Please circle the appropriate option below.

    - less than $5,000

    - $5,000 - $25,000

    - $25,000 - $50,000

    - $50,000 - $75,000

    - $75,000 - $100,000

    - over $100,000

11. What property was damaged? Circle all that apply.

    - significant damages to the house

    - foundation had to be replaced

    - insulation had to be replaced

    - floors had to be replaced

    - electric wiring had to be replaced

    - walls had to be repainted

    - electric freezer(s) had to be replaced

- loss of firewood

- all property was destroyed beyond repair

12. How do you prepare for floods? Circle all that apply.

    - move valuables to higher ground

    - gather documents and valuables for emergency evacuation

    - pack for potential emergency evacuation

    - relocate children and elderly to relatives in other communities

13. How far in advance does the local administration warn you about a potential flood?______________________________

14. What does the local administration do during the breakup? Circle all that apply.

    - forms a local emergency response team

    - monitors the floodwater levels

    - informs population about potential floods

    - assists with evacuations

    - assists with property relocation

    - assists with animal evacuations

15. How do you receive information about an evacuation? Circle all that apply.

    - through relatives and friends (e.g., phone calls, texts, word of mouth)

    - through the local administration (e.g., radio, phone calls)

    - through social media (e.g., Facebook, Twitter)

16. How would you rate the efforts of the local administration during spring flooding? Please circle only one answer.

    - very good

- good

- bad

- very bad

- not sure

17. Do you monitor/follow the breakup? YES/NO

18. If yes, then through which channels do you receive information about the breakup? Circle all that apply.

    - radio (please name the station)

    - relatives and friends that live in the communities upstream

    - National Weather Service River Forecast breakup map

    - other online sources (please specify)__________________

19. Did you receive psychological help after the flood, e.g., counseling? If yes, name the source____________________

20. Did you receive legal assistance? If yes, what kind and who provided the help?___________________________________

21. How would you rate the assistance that you received from the following sources during the flood in May 2013?

	Very Good	Good	Not Sure	Bad	No Help
Alaska Division of Homeland Security and Emergency Management (ADHSEM)					
Red Cross					
Galena City Administration					
Galena Tribal Administration					
FEMA- Federal Emergency Management Agency					
TCC-Tanana Chiefs Conference					
Fait-based organizations					
Neighbors					
Relatives					
Volunteers					

22. How would you rate the assistance that you received from the following sources after the flood in May 2013?

	Very Good	**Good**	**Not Sure**	**Bad**	**No Help**
Alaska Division of Homeland Security and Emergency Management (ADHSEM)					
Red Cross					
Galena City Administration					
Galena Tribal Administration					
Fairbanks North Star Borough					
FEMA- Federal Emergency Management Agency					
TCC-Tanana Chiefs Conference					
Fait-based organizations					
Neighbors					
Relatives					
Volunteers					

23. How would you rate the effectiveness of the following measures?

	Very Good	**Good**	**Not Sure**	**Bad**	**No Help**
Help with paperwork					
Financial reimbursement					
Construction materials					
House reconstruction					
Ice jam and flood prevention measures					
Evacuation					

24. Do you plan to move away from Galena? YES/NO

25. If yes, then it's due to (circle all that apply):

- floods

- poor job opportunities for yourself and/or your spouse

- limited education and medical services

- ability to buy/rent housing in a different place

- health and physical inability to maintain subsistence lifestyle

- desire to move to an urban community

26. Would you support full or partial relocation of Galena? YES/NO

27. How would you rate the quality of drinking water during the flood?

Satisfactory OR Unsatisfactory

28. How long after the flood was the quality of drinking water

unsatisfactory?______________________________________

29. How did you access drinking water during the flood?

____

30. How would you rate the sanitary conditions in Galena during the flood? Circle all that apply.

- destroyed outhouses
- destroyed sewage lagoon
- washed out dump site

31. Did you notice a decline in your health after the flood? If yes, please specify your condition.

____

32. Did you notice an increase in biological threats (e.g., mold, viruses, bacteria)? If yes, then specify the consequences.

- had to replace the foundation and/or the floor
- led to a decline in health

33. What is your gender? MALE/FEMALE

34. How old are you?________________________________

35. How big is your household (excluding you)?____________

36. What is the average yearly income in your household?

-less than $25,000 -$45,000 - 55,000 -$75,000 - 85,000

-$25,000 - 35,000 -$55,000 - 65,000 -$85,000 - 95,000

-$35,000 - 45,000 -$65,000 - 75,000 -over $95,00

2015 FLOOD PLAN
CITY OF GALENA

As break-up of the Yukon River continues the potential for ice jams and flooding is with us again. While forecasters are predicting that this will be a moderate year in terms of flooding potential, we must prepare to care for Galena citizens and property. This plan will assist city officials and others to protect the welfare and the property of Galena residents.

1. This plan is developed to go into effect in stages as the river waters rise. Stages of the plan will be implemented as water levels are reached.

Stage 1: River Level 123' Average Mean Sea Level

1. Radio Station KIYU will give hourly updates on Yukon River water/ice conditions. More frequent updates may be given if major changes occur.
2. City vehicles will be fueled and available for immediate use in the event the plan goes to Stage 2.
3. City Manager will manage activities related to flood preparations, ensuring plan is being followed.

Stage 2: River Level 125' Average Mean Sea Level

1. City Manager will ensure Plan Stage 1 has been implemented and then implement an Incident Command System* management structure.
2. **City Hall (656-1301) will be established as the Command Post and point of public contact for incident-related matters.**
3. The Incident Commander (IC) will meet with team members at the Command Post when Stage 2 of the plan has been implemented. Team members will consist of individuals responsible for the following activities: Security, Facilities Management, and Medical Services.
4. Resources will be staged on or near the dike above Old Town. At minimum, a dumpster, fire truck, water truck, and the city ambulance will be staged.
5. Radio Station KIYU will give hourly updates on Yukon River conditions. More frequent updates may be given if significant changes occur.
6. The IC will notify FAA of possible disruption of power to aircraft navigational aides for inclusion in a Notification to Airmen (NOTAM).

7. The IC will work with the Galena School Principal to send students home or keep them at school depending on conditions and school procedures.

Stage 3: River Level Exceeding 128' Average Mean Sea Level

1. The IC will begin appropriate evacuation announcements on KIYU radio.
2. Electrical power will be shut off in Old Town 20 minutes after making announcement on KIYU radio.
3. Evacuation centers (the dike at the west end of Campion and the City School on Antoski) will be opened to the public.

The Incident Command System (ICS) is a proven way of managing emergencies of all sizes and complexity. It is a temporary management structure set up specifically to oversee and direct an incident.

When implemented, the ICS will have one person who is responsible for all incident activities. He or she will direct others to perform certain functions and jobs as needed.

It is important here to note that the Incident Commander may or may not be the City Manager. Quite likely, it will be someone which the City Manager or Deputy City Manager has appointed to that position, so that he can go on running the other city functions not related to the incident.

In case of flooding, the Incident Commander will designate certain other persons to perform specific duties. The duties he or she might need to have done include security, medical services, and facilities management (water trucks, dike fortification, and evacuation shelters are examples of facilities). These people might utilize others to help them do their jobs. Facilities might designate a truck driver for the water truck; security might employ Troopers to ensure property is protected; and, medical service might use volunteer ETT's to staff the ambulance.

While it is unlikely that this year's break-up will require us to go to an Incident Command System, it will give us an opportunity to fine-tune it in case we ever have to go to it. ICS works if people understand it and work within it.

PREPARING FOR BREAKUP AND FLOODING

COMMUNITY ACTION CHECKLIST

This community action checklist is a guideline for city managers, administrators, and mayors. By going through each item and checking it off when it is accomplished, you can be certain that your city or village is prepared for flooding.

Public Awareness:

- Meet with officials of the city, school, utilities, and clinic to review flood preparations.
- Conduct a publicity campaign to remind people to protect property that might be damaged by flooding and to tell people what to do in case of flooding.
- Conduct a pre-breakup inspection of flood prone areas.

Public Buildings & Records:

- Make sure all important city records are protected from flooding.
- Prepare public buildings for the possibility of flooding. Relocate property to upper levels of flood prone buildings or remove to other safe locations.

Equipment & Vehicles:

- Move all city vehicles and equipment to high ground storage areas.
- Check shop area and work sites to make sure city materials and property are safe from flooding.

Electric Plant:

- Shut down power plant if it is threatened with flooding. Remove batteries.
- Protect the fuel source and shut off valves to prevent spills if lines break.

Fuel Storage:

- Anchor fuel takes to prevent them from floating away in flood waters.
- Make sure valves are shut off to prevent fuel spills if lines break or tanks move.
- Move fuel in barrels and other containers to high ground.

Airport:

- Monitor airport during high water. Report conditions to DOT/PF.
- Move all aircraft to high ground.

Water, Sewer & Drainage Systems:

- Encourage residents to store water.
- Test water after flooding.
- If sewage lagoon overflows, contact State DEC.
- Make sure all culverts and drainage ditches in your community are open and clear of debris.

Telephone:

- Charge the batteries that provide backup power to the telephone system.

Schools:

- Notify school manager of possible need to use school as an emergency shelter. Make sure of access.
- If the school has its own or a backup generator, test it.
- If the school has radio communications, test it.

Community Disaster Assistance:

- Make a list of critical things that have to be done during flooding. Assign someone to each job.
- Prepare to provide shelter and food for people whose homes are flooded.
- If necessary, help people move to shelters. Monitor especially the status of elderly and handicapped people.
- Report on flood conditions to the Department of Homeland Security and Emergency Management (DHS&EM), 907-428-7000 or 1-800-478-2337.

ARE YOU READY FOR A FLOOD???

Winter can't last forever. Soon the weather will be warmer, the birds will be chirping, the sun will be shining. And, YOU'LL BE IN THE WORST DANGER OF FLOODING ALLYEAR.

WHAT TO DO

- Listen for current information on flooding on the radio and TV.
- Contact your city office or insurance agent to find out if flood insurance is available in your community.
- Remember that flooding is serious; make sure your children and pets are safe. Keep them away from culverts and flood waters, and don't leave pets in areas that might be flooded.
- Take measures to protect homes and personal property. Locate problem areas and MOVE PROPERTY TO HIGH GROUND IF NECESSARY (snow machines, chain saws, ATV's, fishing gear, etc.).
- Monitor septic systems, wells, and fuel tanks. Make sure valves are shut so tanks won't spill if flood waters move them.
- Electricity will be shut down if the power plant floods. Be prepared to do without electricity.
- Be ready to be isolated for several days if your airport floods.
- Stock up on food and water.
- Keep a battery powered radio and good batteries available.
- Know where your community shelter is.
- Take all your necessary medications with you.

Appendix D
Peer-to-Peer Project Description

U.S.-Russia Peer-to-Peer Dialogue Initiative 2015-2016

Reducing spring flood impacts for wellbeing of communities of the North

Flood Risk Mitigation | Disaster Response

Goals

- Improve preparedness and response to annual springtime flooding in Alaska and Yakutia
- Foster socioeconomic and ecological wellbeing in rural Arctic communities
- Foster greater contacts between Americans and Russians

Partners

- University of Alaska Fairbanks (UAF), Fairbanks, Alaska, USA
- North-Eastern Federal University (NEFU), Yakutsk, Sakha Republic, Russia

Beneficiaries

- *Residents of Galena and Edeytsy,* who will see how they can take a more informed role in resilience of their communities.
- *Scientists* whose awareness of social and cultural issues will be increased
- *Students* who will become future leaders in mitigating natural disaster risk

Synopsis

This project will foster socioeconomic wellbeing in the US and Russian communities of the North through the development of effective and easily adaptable ice jam and flood risk mitigation, and disaster response and recovery strategies.

In Alaska, US and Yakutia, Russia spring is known as a flood season. Significant funds are spent on challenging annual disaster response and recovery efforts. In addition to the financial losses, spring floods lead to injuries and loss of life, displacement and long-term evacuation of population, damage to cultural or heritage sites, loss of means of livelihood, and ecosystem resource loss.

The project will comprise interdisciplinary *community-based participatory* research, education, and cultural activities that use the flood sites Galena, Alaska and Edeytsy, Yakutia as case studies. A diverse, bilateral team will be established to share experiences and identify best practices in mitigating the risk of and improving response to floods associated with spring breakup in Arctic communities.

The project will inspire a long-lasting collaboration among present and future decision makers and community residents to improve preparedness and response for this seemingly intractable problem that threatens the very existence of northern communities in both countries.

(Left) Galena, Alaska flooded in May 2013; (Right) Village of Edeytsy, Yakutia, Russia flooded in May 2013.